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Science News x

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THE PAST TWENTY YEARS OF PHYSICAL ASTRONOMY[1]

A COMPLETE survey of the progress of physical astronomy during recent years would be so formidable an undertaking that to attempt to cover the entire field would require a whole series of lectures rather than a single evening. So I shall limit myself to the attempt to trace for you the development of only one or two of the more recent conceptions and methods of modern astrophysics and to show how greatly they have enlarged the views which we held, even as recently as the first ten years of this century. From the standpoint both of the results accomplished and the outlook toward the larger problems of astronomy there probably has never been a period quite comparable to that of the past twenty years.

The underlying cause of this remarkable progress has been the intimate relationship which has developed between physics and astronomy, so that important discoveries in the one science have reacted immediately upon the other and found far-reaching applications almost at once. A quarter of a century ago an immense amount of observational material had been collected in our physical laboratories and observatories to the interpretation of which the key was almost entirely lacking. We could hardly hope to understand the behavior of matter in the distant stars when the mechanism of the light given out by a candle flame was still quite unknown to us. So in astronomy, as in physics, a great new field was opened up by the fundamental discoveries of Rutherford, Bohr and many others on the structure of matter and the nature of radiation.

It is a commonplace to say that all our primary knowledge of stars is derived from the light which they give out, where the term *light* is used in a general way to include both visible light and invisible radiation, such as heat or X-rays. From a star's light we can measure its position, its slow movement across the sky, its brightness and its distance, but we can do a great deal more. By analyzing its light we can study its individuality, which is defined almost as uniquely by the faint rays of light which reach us as is the personality of a friend by the actions of his daily life. The main problem of physical astronomy,

[1] Address given in San Francisco on April 16, on the occasion of the presentation of the Bruce medal by the Astronomical Society of the Pacific.

accordingly, is to interpret the inscriptions which we find contained in these stellar records, which we call the spectrum.

To an observer who looks at the stars on a clear night the differences of color are very noticeable. Betelgeuse is red, Sirius is blue-white. If these stars are looked at through a piece of red glass, Betelgeuse still looks bright while Sirius becomes comparatively faint; through blue glass, on the other hand, Betelgeuse is very faint and Sirius remains bright. This means simply that most of the light of Betelgeuse is red light and that of Sirius blue light. If, instead of using colored screens, we look at the stars through a glass prism we obtain all the colors at once drawn out into a band which is known as the spectrum. Red lies at one end and violet at the other, with yellow, green and blue lying between. The red portion of the spectrum of Betelgeuse is very bright and the blue faint, while in Sirius the reverse is the case. We are all familiar with the fact that the color of the filament in the bulb of an electric lamp is red when the voltage is low, and quickly turns to white when the voltage becomes normal. If we should look at its spectrum we should see mainly red light when the filament first begins to glow, and much more blue light as the temperature rises. Hence we can reason directly that the temperature of Betelgeuse is low and that of Sirius very much higher because its blue light is so intense. Actually, the temperature of Betelgeuse is about 3,000° Centigrade (5,400° Fahrenheit) and that of Sirius is about 10,000° Centigrade.

We see then that the band of colored red light which we call the continuous spectrum gives us valuable information regarding physical conditions in the stars. Of much greater importance, however, is the network of dark lines which crosses the continuous spectrum, and which we see when a narrow slit is used in front of our glass prism. A spectrum of lines is formed whenever we heat a gas to the point at which it sends out light. For example, if we look with our prism at one of the long horizontal mercury lamps, used so extensively in the illumination of manufacturing plants, we see a number of colored bright lines. The most intense of these is a green line which is responsible for the rather ghostly color of the light, but there are other lines colored blue, yellow and red. Together these lines form the characteristic spectrum of mercury vapor. In the same way, if we pass an electric current between the ends of two iron rods and form an electric arc, the hot iron vapor gives us some two thousand bright lines, colored according to their position in the spectrum, which are characteristic of iron, and of iron alone. So each element has its own groups of spectral lines which distinguish it uniquely from every other element.

If we now compare directly the lines of the different elements with the dark lines which cross the continuous spectrum of the sun or of most of the stars, we find immediate evidence for the presence of the great majority of the elements in their atmospheres. The lines are dark as seen against the brilliant background, instead of bright as in our laboratory sources, but in number, position and intensity the correspondence is almost perfect. This gives us a means of analyzing the composition of the sun or of the most distant stars which we can observe with our spectroscope. The latest studies of the sun made in this way give definite evidence of the presence of fifty-seven of the elements known to the chemist on the earth. Six have been added to the number within the past few months, and there can be little doubt that all the others are present as well, our failure to observe them being due to physical conditions present in the sun which prevent their spectral lines from appearing with sufficient intensity.

This method of analyzing spectra in a qualitative way has been known for many years. So, too, has the extremely important fact that the spectral lines are displaced by small amounts when the source of light and the observer are approaching or receding from one another. If a star, or the edge of the sun due to its rotation, is approaching us more waves of light reach us in a second than if there were no relative motion. Hence the length of the waves is shortened slightly, and the spectral lines are shifted a trifle from their normal positions toward the violet end of the spectrum. Similarly, if a star is receding from us the displacement is toward the red end of the spectrum. The quantities to be measured are small, but they can be determined with remarkably high precision, and from them we can obtain the motions of the stars toward or away from the earth. This forms one of the most fruitful fields of investigation in all astronomy, for the results derived from it enable us to find at what rate our sun is moving in space, how the motions of the stars in our system are related, and how even the enormously distant universes of stars, the spiral nebulae, are moving with respect to us and to one another. The Lick Observatory was one of the pioneers in this type of research and has maintained its leading position in the accuracy with which it has carried on these difficult and exacting observations. The most recent publication of the Lick Observatory by Dr. Campbell with the collaboration of Dr. Moore forms a landmark in this field, and bears remarkable testimony to the skill and resourcefulness of these two eminent members of our society.

The situation at the beginning of the century as regards the interpretation of spectral lines, how they originate and what information they can give us con-

cerning physical conditions in the sun and stars was much less satisfactory. We knew almost nothing about how an atom gives out light, and the different lines of the spectrum were necessarily classed together in most of our investigations. One important difference, however, had been recognized by Sir Norman Lockyer between some of the lines produced in the electric arc and the electric spark. In the spark spectrum of different elements certain lines were found to be much more intense than in the spectrum given by the arc, and these lines, to which Lockyer gave the name "enhanced," he considered as due to a modified form of the element arising from some sort of decomposition of the atom produced by the high temperature of the spark. In this hypothesis modern research has shown that he was substantially correct.

About 1905 a few studies were commenced which began to throw light upon the differences in behavior among different spectral lines. One of these was made at the Mount Wilson Observatory, and I should like to describe it in some detail, partly because it is of interest historically, but more because it illustrates the extent of the applications which a comparatively simple research may come to acquire. It is one more illustration, so frequent in scientific work, of the old Biblical story of how Saul went out to seek his father's asses and found a kingdom.

One of the earliest photographs of the spectrum of a sun-spot was obtained at Mount Wilson in 1905, nearly all observations before that time having been visual. Now the principal difference between the spectrum of a sun-spot and that of the general surface of the sun consists in the marked change in the relative intensities of great numbers of lines, some being weakened in the spot spectrum and others greatly strengthened. In many cases lines barely visible in the solar spectrum become very prominent in the spot. Many of the weakened lines we soon recognized as being enhanced lines, that is, lines stronger in the spectrum of the spark than of the arc, but we had no adequate explanation to account for the behavior of the strengthened lines. The attempt to find such an explanation was the object of an investigation begun at Mount Wilson a little more than twenty years ago.

As a working hypothesis we made the assumption that the temperature of sun-spots is below that of the general surface of the sun. Our problem, then, was to see whether we could duplicate under conditions of varying temperature in the physical laboratory the observed behavior of the spectral lines in sun-spots. For this purpose we used the iron arc, the supply of electric power on Mount Wilson being at that time quite inadequate for an electric furnace. The method used was to pass a powerful current through the arc and photograph the spectrum: then to reduce the current to as low an amount as possible and on the same plate to photograph the spectrum again. Since the amounts of energy passing through the arc were very different in the two cases it could fairly be assumed that the temperatures were also different. Later we simplified the method by magnifying greater the image of the arc and comparing the spectrum of the outer cooler flame with that of the hotter core near the iron poles.

The study of the photographs at once led to definite results. It was found that many iron lines were relatively much more intense in the flame than in the core of the arc, and that these were without exception just the lines which were strengthened in the spectrum of sun-spots. On the other hand, lines unaffected in different portions of the arc remained essentially unchanged in sun-spots. So we were able to classify the iron spectrum into groups of high and low-temperature lines, and to make an accurate comparison with the corresponding lines in the sun-spot spectrum, which showed remarkably good agreement. Soon afterward some experiments made in Pasadena with an electric furnace of temporary construction showed that the results obtained with the arc were definitely to be ascribed to the effects of temperature, and not to any electrical phenomena present in the arc. Finally, conclusive evidence for the low temperature of sun-spots was afforded by the discovery of the presence of bands in the spectrum, due to the existence of compounds which can exist only at reduced temperatures.

A few years later, when the Pasadena laboratory was completed, a thorough investigation of the spectra of many elements was carried out by Dr. King, and the lines were arranged in classes according to their behavior under known conditions of temperature. These results have confirmed and extended the earlier work at Mount Wilson, and have proved of immense value to all modern investigators who have analyzed spectra and studied the internal structure of the atom.

You will readily see that the discovery of the temperature classification of spectral lines meant much more than a means of interpreting the behavior of lines in the sun-spot spectrum. It formed essentially a new method of attack upon the physical problems of the sun and stars, especially as it was soon supplemented by other results showing the behavior of spectral lines under varying conditions of density and pressure. A partial breach had been in the hitherto almost impenetrable wall surrounding the interpretation of the spectrum.

The fundamental discoveries necessary to the adequate explanation of these results of observation came in the years following 1911 from the physical labora-

tories of Europe. Sir Ernest Rutherford first suggested that an atom of matter is an electrical structure built up out of natural units of positive and negative electricity. The positive charge is concentrated into an exceedingly minute nucleus; the negative charge extends over a relatively much larger region which, however, is only about one one hundred millionth of an inch in diameter. For a dozen years following the work of Bohr, every one thought of the electrons, the units of negative electricity, as describing tiny orbits around the nucleus, like planets around the sun. Now, since Schrödinger has developed his complicated but very successful "wave-theory," we are much less dogmatic about the exact position and motion of the negative electricity. We know, however, that under increasingly violent disturbance the negative charge can be split off from the atom, one natural unit at a time, to escape as free electrons; and we have good reason to believe that some of these unit charges are held very close to the nucleus and firmly bound, while others are near the outside of the atom and much more loosely held. The number of electrons outside the nucleus ranges from one for the simplest atom, hydrogen, and two for the next, helium, to twenty-six for iron, eighty-two for lead, and ninety-two for the heaviest known atom, uranium. A great many of the properties of atoms can be explained by means of a structure of successive shells of electrons. The laws of atomic structure fix the maximum number of electrons which can go into any one shell, so that a heavy atom like one of iron or lead contains several complete shells of electrons and an incompletely filled one on the outside.

Our immediate interest in the atom is concerned with the way in which it gives out or absorbs light. In an atom in its ordinary or normal state all the electrons are as close to the nucleus, which attracts them strongly, as the laws of atomic structure permit them to be. It is possible, however, by various means to raise one or two electrons into new positions which without serious error we may think of as farther from the nucleus. In this condition, known as an "excited" state, the atom is loaded with energy. If left to itself it will usually change back into a less excited state after something like a hundred millionth part of a second, and to do so it has to unload some of its energy, which is given out in the form of light. By a law of nature which appears to be one of the most fundamental that human science has yet discovered, but which remains utterly unexplained, the number of vibrations a second in the emitted light is exactly proportional to the amount of energy which the atom unloads. If this light is observed with a spectroscope we see a sharp line in a position in the spectrum defined accurately by the energy unloaded by the atoms which produced it. Since even the simpler atoms have dozens of excited states and the more complex several hundred—Dr. Russell has found 364 excited states in the case of the neutral titanium atom—the intricate character of the spectrum of many of the elements is easily understood.

In all these excited states the atom retains all its electrons, but it is possible through more violent disturbance, electrical or otherwise, to remove an electron completely. The atom is then called ionized and can exist in many different excited states. Changes between these states produce a whole new spectrum of lines, not one of which except by chance coincides with a line of the neutral atom. There is abundant evidence to show that the enhanced lines of the various elements come from ionized atoms with one electron missing, and the ordinary arc lines from neutral atoms with all their electrons present. Lockyer's bold hypothesis that the atoms giving the enhanced lines are partly decomposed is, therefore, substantially true, only it is a different kind of decomposition from that known to the chemist. It has been found possible to remove not only one, but two, three, or even more electrons from the atom. In these states, however, the energy emitted is usually so great that the resulting spectral lines lie far in the ultra-violet, where we could not observe them in the stars, or even in the sun.

With one more word we shall be ready to apply our knowledge. The spectra of the sun and stars show dark lines. This means that light has been absorbed by the reversal of the process already described. An atom can pick up energy from light passing by it and become excited, rising from a state of lower to one of higher energy: but it can do this only if the number of waves per second in the light is exactly sufficient to furnish the necessary energy for the change. Hence atoms of a given kind absorb a definite set of sharp spectral lines, identical in position with those which they emit. Any particular atom, however, can not absorb all the lines of the spectrum, but only such as correspond to a transition from its particular state to some other, and can absorb only one of these at once. So when we find thousands of absorption lines in the spectrum of iron, we realize that among the trillions of atoms present in the iron vapor thousands of different processes are occurring. The work of the last five or six years has gone so far in the interpretation of complex spectra that we can take almost any line in a stellar spectrum and say not only what sort of atom produced it, but also, so far as energy transitions go, just what the atom was doing at that time.

Suppose now that we have a long tubular electric furnace in our laboratory and pass white light through it. Inside our furnace is a bit of metallic

sodium. At a low temperature, far below a red heat, the sodium begins to vaporize, and in the spectrum of the light which has come through the vapor we find the familiar pair of dark lines in the yellow, as well as others in the ultra-violet. But if we heat our furnace to 2,000° Centigrade we shall find new absorption lines appearing in the orange, the green and the blue, no trace of which could be obtained with the cooler vapor.

The reason is not far to seek. In the cooler vapor practically all the atoms are in the normal state of lowest energy. Such atoms can absorb some of the spectral lines, but not all; and though by this absorption they are raised to excited states each one falls back again so soon that the number of atoms per million which are excited at any given instant is very small. But as we heat our gas hotter and hotter the collisions of its atoms become violent, and as a result a small but steadily increasing fraction of the atoms will be raised to the excited states and absorb other lines.

We see now why the lines belong to different temperature classes and just what these classes mean. The low-temperature lines are absorbed by atoms in unexcited or mildly excited states; the high-temperature lines by highly excited atoms. We see, too, what the relatively great strength of the low-temperature lines in the spectra of sun-spots means. There are more unexcited atoms in the sun's atmosphere above a spot than elsewhere, and this means that the atmosphere there is cooler.

This is not all, however. At a sufficiently high temperature the collisions between the atoms of a gas become so violent as to knock electrons completely off from some atoms and the gas becomes partially ionized. The process is self-limited, since the wandering free electrons will sooner or later meet with other ionized atoms and recombine with them. But the hotter the gas the more numerous will be the ionized atoms and the fewer the neutral atoms. At the temperature of the sun elements which require less energy for the removal of an electron, like calcium or scandium, are very considerably ionized; those which require more, like iron and silicon, are much less ionized. So the enhanced lines of calcium are strong and those of iron relatively weak. Above sun-spots, where the gas is cooler and the proportion of the neutral atoms is greater, the arc lines therefore become stronger, especially for the more easily ionized elements, and the enhanced lines weaker, especially for the elements which are hard to ionize. The combination of these principles affords a detailed and complete explanation of the peculiarities of the sun-spot spectrum which have so long been extremely puzzling.

There is another factor in the process of ionization which is of equal importance in the study of the sun and stars. Let us suppose that we have a mass of gas at a given high temperature. If it is dense the atoms and electrons will be close together, and the chances of their meeting and recombining will be good. But if the gas is allowed to expand and become rarefied the chances of recombination become steadily less. The percentage of atoms which are ionized increases therefore as the pressure diminishes.

This solves a solar puzzle of long standing. At the time of a total eclipse of the sun we can observe its upper atmosphere, the chromosphere, and measure the heights to which the different spectral lines extend. We then find that the enhanced lines of the different elements rise to a much greater height than the low-temperature lines. For example, the H and K enhanced lines of calcium reach a height of seven thousand miles and the blue low-temperature line λ 4227 a height of only three thousand miles. Since the top of the chromosphere should be cooler, if anything, than the bottom, we should expect the low-temperature line to be stronger at the top. The difficulty was solved by Saha, the Indian physicist, in 1920. Though the temperature is probably about the same throughout the depth of the chromosphere, the pressure and density must be far lower at the top than at the bottom. In the lower regions some neutral calcium atoms are present and give the low-temperature line; in the upper regions all atoms are ionized and the line due to the neutral atoms disappears.

One immediate application of this modern theory is to the spectra of the stars. We have every reason to believe that there are no great differences in the composition of the heavenly bodies, and that all the elements recognized upon the earth are present in them. Why, then, do we not see in their spectra the lines of all these elements? The answer is a very simple one. The sun and the stars are too hot or too cold, too rare or too dense to show all the lines at the same time. As we have seen, it takes much more energy to rob some elements of their electrons than it does others. A sun-spot and the red stars are comparatively cool, and the temperature is high enough to bring out strongly only those lines of the elements which require little energy for their excitation. So the low-temperature lines are strong and the lines of ionized elements are weak. At the higher temperature of the general surface of the sun the ionized lines become stronger. When we come to the hottest stars the elements become completely ionized, the lines due to the normal atom disappear and we have a spectrum consisting solely of lines due to very

highly excited atoms. The spectra of the hottest stars, accordingly, are very simple, consisting of lines of ionized helium, doubly and triply ionized oxygen, nitrogen and one or two other elements. It would be quite possible to conceive of a star so hot that it had no lines at all, at least in the part of the spectrum we can observe. The temperatures of the hottest stars we know are certainly upward of 30,000° Centigrade (54,000° Fahrenheit), and may in some cases run as high as 100,000° Centigrade. At somewhat lower temperatures the normal helium lines begin to appear, then the lines of the ionized metals, such as iron, calcium and many others, and finally those due to the neutral atom of these elements. The spectra of the cooler stars, therefore, such as our sun, Arcturus, or Betelgeuse, with temperatures ranging from 6,000° to 3,000°, are very complex and rich in lines, the normal atom of iron alone contributing about two thousand lines to the observable part of the spectrum. Hydrogen is the only element to show lines in the spectra of practically all the stars, affording strong evidence of its extreme abundance throughout all space.

If we know the temperature and pressure of a gas the degree to which an element is ionized can be pretty accurately calculated. As we have already seen, the temperatures of the sun and the stars can be determined from such considerations as the color of their light, and by utilizing our knowledge of the intensities of the enhanced lines we can derive the pressures in the stellar atmospheres. In this way we find that the pressure in the sun's atmosphere is not more than one ten-thousandth part of the earth's atmosphere, and that, though it is many hundreds of miles deep, the whole quantity of gas in it is not more than would be contained in a layer of common air a foot or two thick. This is a very remarkable conclusion, but it is confirmed fully by the fact that a layer of gas in the laboratory an inch thick, and by no means all composed of metallic vapor, will give absorption lines stronger than those in the solar spectrum.

The question may fairly be asked why, if the sun's atmosphere is so very tenuous, we see a sharp edge and do not see down deeper into its interior. Ionization and the free electrons produced by it again give the answer. An ordinary gas, like atmospheric air, scatters a little of the light which passes through it, so that distant mountains, even in the clearest weather, are seen through a bluish haze. Various investigations have shown that an ionized gas acts in the same way, but many thousands of times more strongly, and that the haziness increases very rapidly with the density. Consequently, the sun's atmosphere, even at its very low density, becomes filled with an "electron haze," which prevents us from seeing deeply. Such a great flood of energy is flowing through it from the far interior of the sun that this haze appears intensely luminous and gives us the brilliant visible surface.

Recently we have commenced at Mount Wilson an attempt to determine the relative amounts of the various elements in the atmospheres of the sun and stars. For this purpose groups of related lines called "multiplets" are used, in the production of which it is possible to calculate from theory the relative numbers of atoms involved. On comparing the intensities of these lines in the solar spectrum we find that fully a million times as many atoms are active in producing the strongest lines as in giving one which is barely visible.

Using the same principles in the case of several of the brighter stars whose spectra can be photographed on a very large scale, we find that the amount of vapor of iron, titanium and similar metals in the atmospheres of the great red stars Betelgeuse and Antares is something like one hundred times greater per square mile of surface than for the sun. Most of the stars which have been studied so far are, in reality, far brighter than the sun, and have very extensive atmospheres. Procyon, the only star roughly comparable in brightness to the sun, has about the same amount of atmosphere. In the redder stars the low-temperature arc lines are much stronger, in comparison with the high-temperature lines, than in the sun. When the corresponding numbers of atoms are found, a fairly simple calculation gives the temperatures of the star's atmosphere. The resulting values range from 3,000° for Betelgeuse to 9,900° for Sirius and are in excellent agreement with those found from the color of the light.

The enhanced lines of iron and titanium, due to the ionized atoms, are also stronger in Betelgeuse and Antares than in the sun. In view of the much lower temperature we might expect them to be weaker; and it appears that they must be produced in a region of very low pressure; in other words, in the very extensive chromospheres. The hydrogen lines, which are absorbed only by hydrogen in a highly excited state, might be expected to be weaker in these cool red stars. They are actually stronger than in the sun and appear also to arise in the chromosphere. This apparently chaotic set of facts is brought into intelligible order by the modern theory of stellar atmospheres.

Two things determine the equilibrium of a star's atmosphere, the force of gravity and the amount of heat which flows outward per square mile of its surface. The former controls the rate at which pressure increases in the deeper layers, while the latter fixes the temperature of the visible surface and also provides an upward radiation pressure which holds up

the atmosphere against gravity and makes it far more extensive even in the sun than it would otherwise be. When gravity at the surface is small the pressure and density in the atmosphere are low and the electron haze is thin. We, therefore, see down through more material, and the total quantity of atmosphere above a given area of the surface is large. At the same time, owing to the lower pressure, the gas is more highly ionized than in the sun, and the enhanced lines are relatively stronger. Radiation pressure, moreover, is stronger in comparison with gravity and can support a more extensive atmosphere in which ionization is high. This still further strengthens the enhanced lines, and also those of hydrogen, which, having the lightest atoms, is easily supported.

The special characteristics which are thus broadly outlined are exactly those of the giant stars, while the much fainter dwarfs show the opposite peculiarities. But why should low surface gravity be associated with great brightness in a star? The answer comes from the famous work of Professor Eddington, which shows that the brightness of a star depends mainly on its mass and increases very rapidly as this increases. For stars of the same mass but different sizes both gravity and radiation pressure diminish as the diameter increases, but in the same proportion, and it can be shown from this that the extent of atmosphere will be a good deal the same for all. But for stars of different mass, whatever their size, the radiation pressure increases much faster than does gravity, and the massive stars should have much more extensive atmospheres and chromospheres than the less massive stars.

This brings us at once to the last application which I shall attempt to make of our theory, that to the determination of the intrinsic brightness and distances of stars. Stars may appear bright to us because they are intrinsically very luminous or because they are very near. For example, the two stars Procyon and Betelgeuse appear in the sky of nearly the same brightness. We know, however, that Betelgeuse is very much farther away, and that if they were at the same distance Betelgeuse would appear at least one thousand times as bright as Procyon. We might then say that if the intrinsic brightness or candle-power of Procyon is 1, that of Betelgeuse is 1,000.

It was nearly fifteen years ago that we made our first attempts at Mount Wilson to learn whether the intrinsic brightness of a star had any influence on its spectrum, the work being a direct outgrowth of our study of the sun-spot spectrum and the temperature classification of spectral lines. Knowing from direct measurement the distances and hence the intrinsic brightness of many stars, we could compare directly the spectrum of a very luminous or giant star with that of an intrinsically faint or dwarf star of nearly the same temperature. This showed at once that many of the enhanced lines and those due to hydrogen were very strong in the giants and weak in the dwarfs, while the behavior of other lines, mainly low-temperature lines, was just the reverse. With the aid of stars of known brightness it then proved comparatively simple to establish a relationship which would give us the intrinsic brightness of a star as soon as the relative intensities of these lines were known. The distance is obtained at once from an easy calculation based on the intrinsic brightness, as compared with the apparent brightness in the sky.

The method has two very considerable advantages. It is rapid, since a single photograph of spectrum will yield a value of the intrinsic brightness and distance of a star; and it is applicable to stars whose distances are so great that the usual direct method of measurement can not be used. The nearest star to us is at a distance of twenty-five million million miles, and most of even the brighter stars are from ten to one hundred times farther away. As seen at these greater distances the earth's orbit becomes almost vanishingly small. In the spectroscopic method, however, the intrinsic brightness of a star can be determined equally well whatever its distance. Hence the method has been used extensively at several observatories during recent years, and has nearly tripled the number of stars for which we know the distance.

A very interesting result of this increase in our knowledge of the real brightness of the stars is the extraordinary range which we find. There is a faint star recently observed by van Maanen which gives out only one fifty thousandth part the light of our sun; on the other hand, the bright southern star Canopus is at least ten thousand times as luminous as our sun, and there are doubtless other stars still brighter or fainter than those which have been observed. So we have a range of at least five hundred million, and probably one thousand million, in the quantity of light which the stars are pouring out.

The spectral differences between giant and dwarf stars and the spectroscopic method of deriving the real brightness of the stars find a satisfactory explanation in the theory we have been discussing. Eddington has shown that the intrinsic brightness of a star is directly related to its mass and increases with it. As we have already seen, the more massive a star is, the more extensive is the atmosphere which it can support by the outward pressure of its radiation. Such an extensive atmosphere of low density favors the ionization of the atoms and we should expect to find the enhanced lines strong. On the other hand dwarf stars of small mass would have shallow atmospheres, and we should expect the enhanced lines to be weak and

those due to the normal atom strong. This is in agreement with observation. Our spectroscopic method of finding the real brightness of stars appears, therefore, in the main to be a method of finding their masses. The immense size of such stars as Antares, with a diameter of about two hundred million miles, affords excellent direct evidence for the existence of the extensive atmospheres predicted by our theory.

I realize fully that in this very condensed statement it has not been possible to touch on some of the most interesting developments of modern physical astronomy, such, for example, as the processes which maintain a star's energy, and the source of supply of its enormous radiation. Yet the conception of how modern physics interprets the spectrum and modern astronomy applies it, and how largely both sciences are based upon the ultimate structure of matter and the nature of radiation, is a most illuminating and inspiring one, however inadequately I have been able to bring it before your minds this evening.

WALTER S. ADAMS

MOUNT WILSON OBSERVATORY

CHARLES HENRY GILBERT

DR. CHARLES H. GILBERT was born on December 5, 1859, at Rockford, Illinois, his parents removing later to Indianapolis. He died suddenly at Palo Alto, on April 20, 1928, from a paralytic stroke. His father, Edward Gilbert, came early from Bohemia, becoming an insurance and realty agent and a pillar of the Congregational Church of Oscar McCulloch, widely known as a philanthropist and as a liberal Christian. His mother, Sarah Bean, still vigorous and competent at the age of ninety-three, is a typical representative of the Massachusetts Puritans at their best, and America has no better stock.

Charles was a graduate of the Indianapolis high school, where he found his first scholarly inspiration under Herbert Edson Copeland, a brilliant young naturalist, one of the ablest Cornell has ever sent out, but who died untimely from a fall into White River in January, 1877. From Indianapolis, Copeland transferred him to his intimate friend, the writer, who had become professor of zoology in Butler University at Irvington, then a suburb of Indianapolis. Gilbert took from the University of Indiana in 1883 the degree of Ph.D., the river fishes being his specialty. He had followed Dr. Jordan to the University of Indiana, where he became instructor and later professor in zoology. With the exception of four years as professor at the University of Cincinnati, he was continuously associated with Dr. Jordan, from 1877 to 1928, in Butler University, Indiana University and Stanford University, where he became emeritus professor in 1925.

In 1877, Dr. Gilbert had joined Dr. Jordan in a fish survey of the state of Georgia, a line of research not attempted before. In 1879 he was appointed by Professor Baird as secretary to Dr. Jordan's exploration of the fish fauna of the Pacific Coast, a research occupying most of 1880, and which Gilbert extended to Mazatlán and Panama. For many years the papers of "Jordan and Gilbert" were the most prolific in American ichthyology, their most extended paper being a descriptive "Synopsis of the Fishes of North America" in 1882.

From 1880 to 1928 Dr. Gilbert retained connection with the Fish Commission (later the Bureau of Fisheries). Since the first serious study of the Pacific salmon, by Jordan and Gilbert in 1880, he devoted his scientific work to the five American species of these fishes, until he came to know more of their character and habits than all other men taken together. The demonstration that their individual ages are recorded in their scales is largely his work, though others have made fruitful efforts at the same problem. The clue to his conclusions rests in the fact that in migratory fishes, the rings of growth recorded in the scales are larger and more wide-set during their well-fed life in the sea.

In nearly all the expeditions of Dr. Jordan to various parts of the world, Dr. Gilbert took an active part, as well as conducting others to Alaska, Hawaii, Japan and Panama. The ascent of the Matterhorn in 1881, with Dr. Jordan, Dr. M. B. Anderson and three students, was made at Dr. Gilbert's suggestion. In this adventure he was struck in the face by the fall of a great rock. This kept him, with Jordan, W. W. Spangler and two guides, one the famous Jean Baptiste ("John the Baptist") Aymonod, near the summit all night. His steel-rimmed Derby hat and careful ministrations by his comrades saved his life.

In 1909 Dr. Gilbert assisted the International Fisheries Commission in its salmon investigations, and for the last five summers he devoted himself almost wholly to salmon problems in Alaska.

In 1882 Gilbert was married to a fellow student, Julia Hughes, also interested in zoology and a member of the Matterhorn party. She died in November, 1915. During her life in Palo Alto she was a notable leader in favor of civic betterment. He left three children—Carl Gilbert, an attorney in Santa Fe; Ruth (Mrs. Percy B. Baker), of Atlanta, and Winifred (Mrs. Carl F. Braun), of Pasadena. All these are graduates of Stanford University.

Dr. Gilbert, one of the pioneers of the Stanford faculty, was a man of versatile genius. He had talent as musician and linguist, though his writings and lectures he confined rigidly to aspects of his chosen

specialty. He was one of the most careful and accurate of scientific observers, the keenest and ablest critic in natural history I have ever known, and therefore a most helpful teacher. His attitude was wholly modern, though he had little interest in those writers who, as specialists building on fact, add wide deductions as to what may be, and assuming that all these are sound, frame far-reaching theories of consequences of evolution. Results attained too easily, by analogy and imagination, may be more discouraging to actual workers than ever the most rampant of systematized ignorance.

Dr. Gilbert was a man of rather less than average stature, but agile and wiry. In the words of "John the Baptist," "C'est un homme fort et brave" (a man strong and brave).

DAVID STARR JORDAN

SCIENTIFIC EVENTS

THE INTERNATIONAL DAIRY CONGRESS

THE eighth International Dairy Congress, to be held in Great Britain from June 26 to July 12, will be attended by 30 official delegates from the United States. In addition, a large number of unofficial delegates is expected to attend. The delegation sailed on June 16 on the *Leviathan*.

The seventh congress was held in the United States in October, 1923.

The congress will meet with London as headquarters, but excursions, tours and inspection trips will carry the delegates to practically all points in England. Receptions and numerous conferences for the reading of special papers and studies have a prominent place in the program.

The delegates named by President Coolidge to represent the United States are:

R. W. Dunlap, assistant secretary of agriculture, Washington, D. C.

Dr. L. A. Rogers, acting chief, Bureau of Dairy Industry, Department of Agriculture.

Roy C. Potts, chief, dairy marketing division, Department of Agriculture.

Dr. G. E. Sherwood, dairy farmer, Kimball, Minn.

A. J. Glover, editor, *Hoard's Dairyman*, Fort Atkinson, Wis.

J. D. Mickle, state food and dairy commissioner, Portland, Ore.

Professor J. B. Fitch, Kansas State Agricultural College, Manhattan, Kans.

A. M. Loomis, American Dairy Federation, Washington, D. C.

P. H. Kasper, cheese manufacturer, Bear Creek, Wis.

Professor A. A. Borland, Pennsylvania State College, State College, Pa.

Professor O. E. Reed, Michigan Agricultural College, East Lansing, Mich.

Dr. C. W. Larson, director, National Dairy Council, Chicago, Ill.

Dr. H. E. Van Norman, American Dry Milk Institute, Chicago, Ill.

D. M. Dorman, president, the California Dairies, Los Angeles, Calif.

A. L. Haecker, president, Allied State Creamery Association, Lincoln, Nebr.

Harry Bull, secretary, Dairymen's League, Orange County, New York.

Judge J. D. Miller, president, National Cooperative Milk Producers' Federation, New York City.

E. T. Rector, president, Fairmount Creamery Company, Omaha, Nebr.

W. J. Schilling, president, Twin City Milk Producers' Association, St. Paul, Minn.

Fred Rasmussen, secretary, International Association of Ice Cream Mfrs., Harrisburg, Pa.

E. M. Bailey, president, American Dairy Federation, Pittsburgh, Pa.

Dr. Robert S. Breed, bacteriologist, Agricultural Experiment Station, Geneva, N. Y.

T. H. McInnerney, president, National Dairy Products Corporation, New York, N. Y.

Dr. E. B. Meigs, Bureau of Dairy Industry, Department of Agriculture, Washington, D. C.

Frank S. Harmon, director of the Ohio Guernsey Breeders' Association, Cleveland, Ohio.

H. W. Jeffers, Walker-Gordon Laboratory Company, Plainsboro, N. J.

O. S. Jordan, president, Dairy and Ice Cream Machinery and Supplies Assn., New York City.

John Rundall, De Laval Separator Co., Chicago.

Professor George B. Caine, Utah Agricultural College, Logan, Utah.

Professor O. F. Hunziker, Blue Valley Creamery Company, Chicago.

THE UPPER KLAMATH WILD-LIFE REFUGE

BY executive order President Coolidge recently set aside for use as a refuge and breeding ground for birds and wild animals an area in southern Oregon embracing certain unappropriated public lands near the upper end of Upper Klamath Lake. The new reservation will be known as the Upper Klamath Wild Life Refuge and will be administered by the U. S. Bureau of Biological Survey. All the lands involved have been withdrawn for reclamation purposes in connection with the Klamath irrigation project in Oregon and California and, as with other reclamation projects set aside as wild-life refuges, are primarily under the jurisdiction of the Bureau of Reclamation of the Department of the Interior. The reservation of these lands as a bird refuge, therefore, is subject to use by the Bureau of Reclamation for irrigation and other purposes. A federal announcement says:

About 5,200 acres are included in the refuge, which extends as a rather long narrow strip between the Crater National Forest, embracing the high mountain range bordering this part of the Klamath River Valley on the west and Upper Klamath Lake. The refuge area consists mainly of marshland containing a dense growth of tules, sedges and other aquatic vegetation and affording abundant cover for the nesting wild fowl of the region. The marshes and the more open water areas also included will provide important feeding and resting grounds for migratory waterfowl, especially wild ducks and geese.

The establishment of the refuge will be of great importance to the waterfowl of the region, in view of the fact that there has been such extensive drainage of marsh areas in that general section in connection with the reclamation of lands for agricultural purposes. The reservation will be of great interest to conservationists generally as well as to sportsmen who are familiar with the drainage operations that have led to the practical elimination of Lower Klamath Lake, embracing about 80,000 acres and formerly one of the most important breeding grounds for resident waterfowl and feeding and resting grounds for migratory waterfowl in Western North America.

The creation of the refuge at Upper Klamath Lake will in a way serve to offset the disappointment that many felt because of the impracticability of reflooding Lower Klamath to save it as a wild-fowl haven. The development of wild-life refuges in this general section will provide for the needs of the birds on an important migration route near the Pacific Coast.

The new refuge will also extend needed protection to fur-bearing animals. It is unlawful, within the reservation, wilfully to set on fire any timber, underbrush, or grass, or after building a fire to leave it without totally extinguishing it; or to hunt, trap, capture or wilfully disturb any wild animal or bird or the eggs of any wild bird, except under such rules and regulations as may be prescribed by the secretary of agriculture.

A FOUNDATION FOR THE STUDY OF CHILDREN'S DISEASES AT YALE UNIVERSITY

PRESIDENT JAMES ROWLAND ANGELL, of Yale University, has announced that a gift of $1,000,000 has been made by A. E. Fitkin, of New York City. The foundation established by this gift is to be known as the Raleigh-Fitkin Memorial fund, in memory of Mr. Fitkin's son. Under the terms of the gift, a building is to be erected which will be known as the Raleigh-Fitkin memorial pavilion; which will cost $500,000, and which will be dedicated to the care of children. The remainder of the fund will be used as a permanent endowment fund, and will be administered by Yale University to further the objective of Mr. Fitkin's gift.

In announcing the gift, President Angell said:

> It is with great gratification that I announce a most welcome gift to Yale of one million dollars, for the establishment of a foundation for the care of children, both from the standpoint of curative and preventive medicine, the study of children's diseases, and the training of men for the achievement of these purposes. It would be difficult to exaggerate the value of this first step in the completion of the plans made by the General Hospital Society of Connecticut and Yale University for the further consistent development here of a medical center of the highest character and of constantly increasing public service. Not only to the children of this community, but to children everywhere, both in the prevention and in the cure of disease, the work of the memorial will be of inestimable value. Reinforced by all the resources of the hospital and the medical school for the alleviation of every form of human suffering, the memorial will be able to multiply by many times its usefulness to the children for whom it is established.

THE AMERICAN EXECUTIVE COMMITTEE OF THE WORLD ENGINEERING CONGRESS

ADEQUATE presentation of America's engineering and industrial story at the sessions of the World Engineering Congress to be held in Tokio next year was discussed at a meeting of the executive committee of the American general committee for the congress held in the Engineers Club, New York, on May 18. Another outstanding feature was presentation of the report of Maurice Holland, executive secretary of the American committee.

Hospitality to be extended in the United States to European delegates in their movement from the Atlantic to the Pacific on the way to the Tokio congress was another subject which came up at the meeting. The entertainment committee reported that local engineering societies already have volunteered their services as hosts to the delegates from Europe.

Importance of careful selection of papers to be read as reflecting the status and tendencies of each of the major branches of engineering in this country was stressed in the report of the technical program committee, headed by Professor Dugald C. Jackson. The program group will call on the societies specializing in the different branches of industry for help in selecting authors for the American engineering papers. Since their acceptance would interfere with adequate presentation of the larger developments of engineering in the United States, miscellaneous papers will not be accepted for reading at the congress.

Professor Jackson announced the following as members, with himself, of the technical program committee: Allen Hazen, *vice-chairman;* H. Foster Bain, Alex Dow, W. F. Durand, J. R. Freeman, Bancroft Gherardi, George W. Fuller, F. L. Hutchinson, Major-General Edgar Jadwin, Dean Dexter S. Kimball, of the school of engineering of Cornell University; A. D.

Little, Fred R. Low, O. C. Merrill, Professor Michael I. Pupin, Calvin W. Rice, George T. Seabury, George Otis Smith and W. E. Wickenden.

Secretary Holland's report covered important phases of the work of the American committee, which is coordinating participation of engineering and industry in the United States in the Tokio sessions. The report went into the matters of coordination of activities, committee progress, financing, promotion and attendance and entertainment. Likewise, the need for further information from Japan on its own engineering and industrial conditions and progress was stressed.

SCIENTIFIC NOTES AND NEWS

DR. JAMES KENDALL, chairman of the department of chemistry, Washington Square College, New York University, has been elected an honorary member of the American Institute of Chemistry. On May 17 the department of chemistry of Washington Square College tendered him a farewell dinner, at which fifty-nine members were present. Dr. Kendall will soon leave to take up his duties as professor of chemistry at the University of Edinburgh.

THE highest award of the American Medical Association for achievement in scientific research, a gold medal, has been awarded to Surgeon Edward Francis, of the United States Public Health Service, for his "thorough and important scientific contributions to the knowledge of tularaemia."

THE Albert medal of the Royal Society of Arts has been awarded to Sir Ernest Rutherford, for his pioneer researches into the structure of matter.

IN connection with the International Geographical Congress in July, honorary degrees of Sc.D. are to be awarded by the University of Cambridge, to General Vacchelli, surveyor-general of Italy, the president of the congress, to Professor E. de Martonne, of the Sorbonne, and to Sir Charles Close, president of the Royal Geographical Society.

DR. GILBERT NEWTON LEWIS, professor of chemistry at the University of California, was the recipient of the honorary degree of doctor of science from the University of Wisconsin at the commencement exercises on June 18.

PRINCETON UNIVERSITY has conferred the honorary degree of doctor of science on Dr. Robert A. Millikan, director of the Norman Bridge laboratory of physics at the Pasadena Institute of Technology, and on Dr. Rudolph Matas, emeritus professor of surgery at Tulane University.

DR. G. CANBY ROBINSON, director of the medical center to be erected by Cornell University and New York Hospital, received the honorary degree of LL.D. from Washington University, on June 5, in recognition of his services to the university and of his contributions to medicine.

DR. HERBERT E. IVES, physicist at the Bell Telephone Laboratories, New York, received from Dartmouth College the honorary degree of doctor of science on June 19.

RUTGERS UNIVERSITY has conferred the honorary degree of doctor of laws on Dr. H. N. Davis, president-elect of Stevens Institute, and the degree of doctor of science on Dr. Frank B. Jewett, president of the Bell Telephone Laboratories, and on Edgar D. Tillyer, optical designer for the American Optical Co.

AT its commencement on June 4, Franklin and Marshall College conferred the honorary degree of doctor of science on Professor David Riesman, of the University of Pennsylvania.

WILLIAM BEEBE, of the New York Zoological Society, received the honorary degree of doctor of science from Colgate University on June 11 and that of doctor of letters from Tufts College on June 18.

THE Republic of France has named Professor G. S. Whitby, of the department of chemistry at McGill University, "officier d'académie," this honor being the first grade of the decoration "officier de l'instruction publique."

DR. E. P. WIGHTMAN, of the research laboratory of the Eastman Kodak Company, Rochester, N. Y., has been elected a fellow of the Royal Photographic Society of Great Britain.

DR. A. M. HANSON, of Faribault, Minnesota, was awarded the prize of $250 by the Minnesota Society of Internal Medicine at its last meeting held in Duluth on May 5. This is an annual prize awarded by the society to the general practitioner in the state who has made the most important contribution to medicine during the year. The prize was awarded to Dr. Hanson in recognition of his work in the isolation of the hormone of the parathyroid gland.

THE first award of the University of Buffalo medal in ophthalmology was made at the recent commencement to Dr. Edmund B. Spaeth, of Philadelphia, for his contributions to the field of ophthalmic plastic surgery. Annual award of the medal is made possible by the gift of a sum of money by Dr. Lucien Howe, professor emeritus of ophthalmology at the university.

DR. RALPH A. FENTON and Dr. Olof Larsell, of the University of Oregon Medical School, were awarded the Casselberry prize of $500 by the American Laryngological Association for work on the pathway of pain referred to the ear in nose and throat diseases.

THE second annual award of the orthopedic scholarship of the Hospital for Joint Diseases, New York, of $2,400 yearly, bequeathed by Henry W. Frauenthal, founder of the hospital, was given to a member of the intern graduating staff, Dr. David Sashin.

THE first award of the Alexander Brown Coxe memorial fellowship, at Yale University, with a stipend of $2,500, for research in the biological sciences, has been awarded to Dr. Ezra A. Sharp. Dr. Sharp will do research work in immunology and pathology.

AFTER a continuous service of forty years, Dr. George H. Monks has retired from the active teaching staff of the Harvard Dental School. In view of his long-continued, devoted and valuable work for the school and the dental profession, the alumni council has voted that an oil portrait of Dr. Monks be hung in the halls of the school.

DR. EDWARD B. GLEASON, professor of otology in the University of Pennsylvania Graduate School of Medicine, was guest of honor at the fourth annual dinner of the Physicians' Square Club, on May 25, in recognition of his having completed fifty years in the practice of medicine.

PROFESSOR A. W. PORTER, F.R.S., is retiring from the chair of physics at University College, London. He was entertained at dinner in the college on June 25 by present and past members of the College Mathematical and Physical Society.

DR. FREDERICK E. BREITHUT, of the College of the City of New York, has been elected president of the American Institute of Chemists.

AT the twelfth annual meeting of the National Board of Medical Examiners, Washington, D. C., on May 3, Dr. Evarts A. Graham, professor of surgery, Washington University Medical School, St. Louis, was elected to membership to succeed Dr. John M. T. Finney, Baltimore, whose term expired.

PROFESSOR G. S. WHITBY, of McGill University, was elected president of the Canadian Chemical Association at the eleventh annual Dominion Chemical Convention held at London, Ontario, from June 6 to 8. This newly-formed association will embrace all local chemical organizations in Canada.

PRESTON S. ARKWRIGHT, of Georgia, was elected president of the National Electric Light Association at the convention held in Atlantic City.

DR. HERMANN J. MULLER, professor of zoology in the University of Texas, has been awarded the university research professorship, under the provisions of which he will have most of his time free for research.

DR. GEORGE T. PACK has resigned from his post of professor of pathology and assistant dean of the school of medicine at the University of Alabama, to accept a three-year fellowship appointment at the Memorial Hospital for malignant diseases, in New York City.

ARTHUR LOWELL BENNETT, who has been at the Lowell Observatory the past two years, has been appointed to the Thaw fellowship in astronomy at Princeton University.

DR. WALTER N. EZEKIEL, formerly National Research Fellow in botany at the University of Minnesota Agricultural Experiment Station, has been appointed to succeed Dr. L. J. Pessin as plant pathologist in the cotton root rot project of the Texas Agricultural Experiment Station.

DR. CARL O. LAMPLAND, of the Lowell Observatory, Flagstaff, Arizona, has been appointed an exchange professor at Princeton University in exchange for Professor Raymond S. Dugan.

DR. CLARENCE F. JONES, of the department of geography at Clark University, and Dr. C. F. Marbut, chief of the U. S. Bureau of Soils, will make a tour of northern South America this summer to make a study of the agriculture of that region.

ALEXANDER SILVERMAN, head of the department of chemistry at the University of Pittsburgh, sailed on May 18 for a three months' tour of Europe. Professor Silverman will accompany the tour of the American Ceramic Society and will later visit educational institutions, museums and glass factories in France, Switzerland, Italy, Austria, Germany, Czechoslovakia, Belgium, the Netherlands, England and Scotland.

F. W. PETTEY, senior entomologist of the Union of South Africa, is visiting the United States on behalf of the South African government to study the work of agricultural experiment stations. He will represent South Africa at the International Congress of Entomology in Ithaca, N. Y., in August.

L. E. S. EASTHAM, lecturer in advanced and economic entomology at the University of Cambridge, has been appointed to represent the university at the International Congress of Entomology.

DR. T. SHIRAKI, of the Government Experiment Station at Formosa, who has been spending some time in European museums, recently spent a week at the U. S. National Museum for the purpose of studying type specimens of Japanese and other Oriental insects.

AT the thirty-seventh annual general meeting of the Institution of Mining and Metallurgy, held in London

on May 17, the Honorable Peter Larkin, high commissioner for Canada, presented to the institution on behalf of Canadian friends and admirers of the late Dr. Willet G. Miller, provincial geologist for Ontario, a replica of the portrait of Dr. Miller which is now hanging in the Ontario Parliament Buildings.

Nature states that one of the houses occupied by Newton when living in London stood on the corner site between St. Martin's Street and Orange Street, where the Westminster City Council is now erecting a new public library, and that the council has decided to commemorate Newton's connection with the site by cutting an inscription on the stone face of the building to read as follows: "Sir Isaac Newton lived in a house on this site, 1710–1727."

DR. ROBERT EDGAR ALLARDICE, emeritus professor of mathematics at Stanford University, died on May 6, aged sixty-six years.

E. T. MEREDITH, editor and publisher of farm journals and formerly secretary of agriculture in President Wilson's cabinet, died on June 17, aged fifty-one years.

THE personnel of the division of chemistry and chemical technology of the National Research Council for 1928–29 will be as follows: George A. Hulett, Princeton, *chairman;* W. C. Geer, New Rochelle, N. Y., *vice-chairman;* Roger Adams, University of Illinois; Marston T. Bogert, Columbia University; R. M. Burns, Bell Telephone Laboratories; W. M. Clark, the Johns Hopkins Medical School; James B. Conant, Harvard; William J. Hale, Dow Chemical Company; Harry N. Holmes, Oberlin College; Charles A. Kraus, Brown University; S. C. Lind, University of Minnesota; Edward Mack, Jr., Ohio State University; H. S. Miner, Welsbach Company; James F. Norris, Massachusetts Institute of Technology; Charles L. Parsons, Washington, D. C.; C. L. Reese, E. I. du Pont de Nemours and Company; C. M. A. Stine, E. I. du Pont de Nemours and Company; W. T. Taggart, University of Pennsylvania; E. W. Washburn, Bureau of Standards; Frank C. Whitmore, Northwestern University.

IN response to an invitation issued by G. Albini, Senator, rector of the University of Bologna, and the president of the organization committee of the International Congress of Mathematicians, the American Mathematical Society has named six persons as follows: Professor R. C. Archibald, Brown University; Professor G. D. Birkhoff, Harvard University; Professor H. F. Blichfeldt, Stanford University; Professor Edward Kasner, Columbia University; Professor Oswald Veblen, Princeton University; Professor Virgil Snyder, Cornell University. Should a chairman be necessary President Snyder has appointed Professor G. D. Birkhoff to act.

FROM May 22 to 24 the Royal Society of Canada met west of Ottawa for the first time. The sessions were held in Winnipeg in the University of Manitoba and the legislative building. Dr. A. H. R. Buller, professor of botany in the University of Manitoba, delivered the presidential address on "The Plants of Canada, Past and Present," and Dr. J. J. R. Macleod, recently appointed Regius professor of physiology in the University of Aberdeen, gave the annual popular address, selecting as his subject "The Air we Breathe." Thirty-eight papers on history and literature, and 179 papers in the various sciences, were communicated to the five sections of the society. M. Camille Roy, of Laval University, Quebec, was elected president, and Professor A. S. Eve, F.R.S., vice-president, for 1928–29.

A CONFERENCE was called by the Federal Horticultural Board at the U. S. Department of Agriculture, Washington, D. C., for June 27, for the purpose of considering the advisability of modifying the requirements governing the interstate movement of five-leafed pines and of currant and gooseberry plants on account of the white pine blister rust. Fifteen states have been designated by the Secretary of Agriculture as infected with this disease, namely: Connecticut, Idaho, Maine, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New York, Oregon, Pennsylvania, Rhode Island, Vermont, Washington and Wisconsin. Five-leafed pines originating in these states are not at present allowed to be moved into non-infected states nor from heavily to more lightly infected ones.

AT the annual meeting of the British Association to be held in Glasgow from September 5 to 12, Sir William Bragg, who succeeds Sir Arthur Keith as president, will deliver an address on the subject of "Craftsmanship and Science" at the inaugural general meeting in St. Andrew's Hall. Dame Helen Gwynne-Vaughan, professor of botany at Birkbeck College, London, has accepted the office of president of Section K (botany) of the association, and will address the section on the subject of "Sex and Nutrition in the Fungi." Professor R. H. Yapp was originally elected president of the section, but resigned when he found he was unable to attend the meeting. Further details of the meeting were printed in SCIENCE for June 15, page 599.

AN international conference on the physical, biological and therapeutical aspects of light will be held at Lausanne from September 10 to 12, and the following day will be spent at Leysin. According to the

British Medical Journal, the subjects to be dealt with include a lecture on the therapeutic, prophylactic and social aspects of heliotherapy, by Dr. Rollier; heliotherapy in Belgium; radiation of food; a lecture on the sun and artificial light, by Professor Leonard Hill, and pigmentation caused by light. Inquiries should be addressed to the Secrétariat Général de la Première Conférence Internationale de la Lumière, Lausanne, Switzerland.

CHARLES F. BRUSH, inventor of the arc light, has set aside $500,000 to establish a foundation to be known as the Brush Foundation, in the memory of the inventor's son, Charles F. Brush, Jr., who died a year ago. The income is to be used by a board of managers to finance efforts contributing toward the betterment of the human stock and toward regulation of increase in population, to the end that children shall be begotten only under such conditions as make possible a heritage of mental and physical health and favorable environment. Those named to administer the fund are: Dr. T. Wingate Todd, Western Reserve University; the Reverend Joel B. Hayden, Mrs. Charles F. Brush, Mrs. Roger P. Perkins, Mrs. William H. Weir and Jerome C. Fisher, attorney.

RECENTLY a group of public-spirited laymen, acting through Dr. Edward L. Keyes, president of the American Social Hygiene Association, invited a group of syphilologists and investigators interested in syphilis to meet at the Hotel Plaza, New York City, for the purpose of organizing the Committee on Research in Syphilis. While the importance of syphilis is well known to the medical profession, large funds for the systematic study of the disease have, with the exception of the government appropriations during the war, been exceedingly difficult to obtain. The Committee on Research in Syphilis will distribute annually through its subcommittees the funds made available by the group of donors, to subsidize and develop research in both the clinical and laboratory aspects of the disease. It is the purpose of the committee to expend the sums placed at its disposal in the development of a constructive program of research with planned activities and selected cooperators, and, upon the stimulation through grants, of researches already in progress or about to be undertaken. There will be for the present, at least, no investment in plant.

A GIFT of $250,000 to the University of Pennsylvania for the establishment of a foundation to study the prevention of diseases of the heart and circulatory system has been made by Edward B. Bobinette, of Philadelphia. It is announced that Mr. Bobinette plans to give additional funds to the foundation.

A RESEARCH FUND of $7,500 per year has been placed in the school of engineering of the Johns Hopkins University by the Utilities Research Commission of Illinois for an investigation of the properties of impregnated paper as used in the insulation of high voltage cables. The work will be under the direction of Dr. J. B. Whitehead, professor of electrical engineering. Dr. Whitehead is chairman of the committee on electrical insulation of the National Research Council, and the work referred to is part of the coordinated plan which is being proposed by that committee. Other similar investigations under Dr. Whitehead's direction are the influence of air and moisture in impregnated paper, supported by the National Electric Light Association, and dielectric absorption, supported by the engineering foundation, with the cooperation of various electrical industries.

THE family of the late Fred C. Bowditch has presented his collection of Coleoptera to the Harvard Museum of Comparative Zoology. There are two principal portions: a general collection of Coleoptera of the world based on the G. D. Smith collection, and a special collection of the Chrysomelidae, containing the Jacoby collections (except part of the second), the Tring Museum collection, and an enormous amount of other material. This is said to be the largest private collection of beetles ever made.

UNIVERSITY AND EDUCATIONAL NOTES

PRESIDENT LOWELL, of Harvard University, has announced gifts of $6,146,000 made to the university during the past year. This includes $350,000 which has been offered for a new gymnasium, and $350,000 to come from two anonymous donors, gifts not previously made public. President Lowell announced also that the $1,000,000 Arnold Arboretum fund has been fully subscribed.

THE $1,000,000 mark in the alumni fund of Princeton University for increasing faculty salaries has been passed. The goal is $2,000,000.

GIFTS for Washington University totaling $1,186,444 were made public at the commencement exercises.

SUBSCRIPTIONS totaling $1,000,000 have been received by the University of Southern California for its semi-centennial fund.

THE following changes were made relative to the personnel of the faculty of the school of medicine at a recent meeting of the board of trustees of Vanderbilt University: The resignation of Dr. G. Canby Robinson was accepted and Dr. W. S. Leathers, professor of preventive medicine, was elected as dean of the school; Dr. C. Sidney Burwell was made professor of medicine and physician-in-chief of the hospital;

Dr. Hugh Morgan was promoted from an associate professorship to a professorship of clinical medicine, and Dr. Horton Casparis was made professor of pediatrics and head of the department.

AT Yale University, Elliott Dunlap Smith, of the Dennison Manufacturing Company, has been appointed professor of industrial engineering in the Sheffield Scientific School; Dr. John Rodman Paul has been appointed assistant professor of medicine, and Dr. Roland Charles Travis has been appointed research associate in psychology, with the rank of assistant professor, in the institute of psychology.

PROMOTIONS which have been recently announced in the department of chemistry, University of Wisconsin, are: from associate professor to professor, Homer Adkins and Farrington Daniels; from assistant professor to associate professor, George J. Kemmerer, S. M. McElvain and H. A. Schuette.

DR. FLORENCE PEEBLES, lecturer for the extension department of the University of California at Los Angeles, has been appointed professor of biology in the California Christian College in Los Angeles.

A. BRAZIER HOWELL, of the U. S. National Museum, has been appointed lecturer in comparative anatomy in the department of anatomy at the Johns Hopkins Medical School.

DR. ERICH VON GEBAUER-FÜLNEGG, assistant professor at the University of Vienna, has received a similar appointment on the chemistry staff of Northwestern University.

R. A. WARDLE, lecturer in economic zoology in the University of Manchester, has been appointed to the chair of zoology in the University of Manitoba, Canada.

DISCUSSION AND CORRESPONDENCE

AN OLD EXPERIMENT ON COLLISIONS OF THE SECOND KIND

THIRTY-SEVEN years ago, in the course of an investigation on the spectroscopic determination of potassium, F. A. Gooch and T. S. Hart[1] made the interesting observation that the presence of sodium in a flame tends to increase the intensity of the red potassium doublet. A small helix of platinum wire was dipped in a solution of potassium and sodium chloride, dried and introduced in the outer cone of the flame of a large Bunsen burner. The potassium line was observed in a small spectroscope with the telescope set so that the yellow sodium doublet fell outside the field of view. The effect of varying the amount of sodium was roughly studied. The phenomenon began to be noticeable when the ratio of sodium to potassium was about ten. With twenty times as much sodium as potassium the potassium line was "much stronger" than in the absence of sodium. The greatest enhancement was observed when the ratio of sodium to potassium was one hundred. A further increase in the amount of sodium decreased the effect, but this decrease may be psychological, due to the strong sodium light scattered into the field of view.

The explanation of this phenomenon, which Gooch and Hart attribute to some, not specified, chemical reaction, is undoubtedly to be found in the so-called atomic collisions of the second kind.[2] Since the resonance potential of sodium is greater than that of potassium, it is possible for an excited sodium atom, colliding with a normal potassium atom, to transfer enough energy to excite the latter. The presence of a large number of excited sodium atoms will, therefore, increase the number of excited potassium atoms and thus enhance the intensity of the potassium doublet.

J. RUD NIELSEN

UNIVERSITY OF OKLAHOMA

ANOTHER WILD LIFE PRESERVE NEAR ITHACA

IN 1919 through the generosity of the late Mr. C. G. Lloyd, of Cincinnati, Ohio, Cornell University obtained what is now known as the Lloyd-Cornell Wild Life Reservation near McLean, N. Y. This preserve comprises an area of slightly over 80 acres and includes several very interesting cold upland sphagnum-heath bogs, grass bogs and an open mud pond, which is now in the process of being slowly filled in. Each year various classes in the biological sciences of Cornell University make excursions to this preserve and in 1926 a report was published on a preliminary survey of the fauna and flora of this preserve.[1]

In 1924 Mr. Lloyd purchased another tract of more than 400 acres of wooded land near Slaterville, N. Y., some 12 miles to the southeast of Ithaca and this has been designated as the Lloyd-Cornell Wild Flower Preserve. This preserve consists of a wooded hilly upland area which is traversed by several streams as well as by a cold spring brook and affords another bit of area in which Nature will be allowed to function without interference from man.

Just before his death Mr. Lloyd made arrangements for the purchase of still another tract of land near

[1] F. A. Gooch and T. S. Hart, *Am. J. Sci.*, 42, 448 (1891).

[2] O. Klein and S. Rosseland, *Zeitschr. f. Phys.*, 4, 46 (1921); J. Franck, *Zeitschr. f. Phys.*, 9, 259 (1922).

[1] A Preliminary Biological Survey of the Lloyd-Cornell Reservation, by members of the Scientific Staff of Cornell University. Bull. Lloyd Library, No. 27, Ent. Ser. No. 5, 1926.

Ringwood which the limnology classes in Cornell University have frequently for many years. Negotiations for the acquisition of this property have now been completed and this preserve will be known as the Lloyd-Cornell Ringwood Wild Life Preserve.

The Ringwood Preserve lies about 7 miles to the east of Ithaca. It comprises an area of slightly over 110 acres. Situated in the midst of rolling wooded hills, it lies at an elevation of about 1,600 feet. Being of morainic origin the glaciers upon receding have left a series of pot holes which are furnishing some very interesting situations for biological studies. One of these pot holes, known as Winterberry pond, seems to be spring fed and retains approximately the same amount of water the year round. The other pot holes have water in them intermittently. In the spring when the snow begins to melt, the water collects in them to a depth of from 5 to 12 feet, while during the late summer the water becomes lower and lower until in the fall the water disappears entirely. Just to the east of the preserve is found a sphagnum bog which offers a variety of biological forms for study.

The life which is found in these temporary pot-hole pools forms an interesting succession study. Every spring during the latter part of April and the early part of May these temporary pools are fairly alive with the beautiful fairy shrimps, *Enbranchipus gelidus*. Coming back to these pools a week or two later not a single specimen of the fairy shrimp will be noticed. However, another crustacean, *Limnetes gouldii*, is found to be just as abundant as was the fairy shrimp a few weeks previously.

Mr. W. C. Senning, instructor in the department of zoology, has made a study of the plant and animal life of these pools during the last three years so that we have a good beginning of a systematic study of the life in this preserve.

With these three Wild Life Preserves made possible through the generosity of Mr. C. G. Lloyd, Cornell University will always have an opportunity of studying plant and animal life in situations where artificial interference by man has been reduced to a minimum.

P. W. CLAASSEN

CORNELL UNIVERSITY

ÅNGSTRÖM IN ENGLISH

Is it not unreasonable to muster the letter E, as appears imminent, into duty for almost any vowel? Something may be said for the simplification achieved in using E for the sounds represented in the original German, Swedish, etc., by Ä (or in Latin by AE). But it seems to be overdoing the point to render the ō sound of the Swedish letter Å with an E, as is done (through a misprint?) in "engstrom units" appearing above the name of Alfred F. Hess on page 334 of SCIENCE (March 30, 1928). Preservation of the original spelling of Ångström's name is perhaps too much to expect, especially of American typewriters. Nevertheless, to convert it to *engstrom* is unduly to succumb to a somewhat prevalent ignorance of the fact that *ongstrum* is in English the nearest phonetical rendering of the physicist's name (cf. Webster's New International Dictionary). Perpetuating the error fails to simplify international scientific intercourse.

E. F. B. FRIES

EMBRYOLESS SEEDS IN CEREALS

OF interest in connection with the theory of double fertilization in angiosperms is the discovery of embryoless seeds in wheat, rye and bald barley. Such seeds develop endosperm which is perfectly normal, but they show no trace of embryo tissue. The abnormality is not apparent on casual observation, but upon closer examination the lack of embryo is evidenced by a depression at the proximal end of the seed. Microscopic examination of sections also shows embryo tissue and the epithelial layer to be absent.

Pope and Harlan reported the occurrence of five barley seeds in which the embryo was entirely lacking among many thousands examined. The writer finds that embryoless seeds occur in wheat in the proportion of approximately 0.1 per cent. Sufficient additional work has been done to indicate that this same proportion holds true for both bald barley and rye.

MILDRED E. LYON

BOTANICAL SECTION,
COLORADO EXPERIMENT STATION

THE HOST OF THE BROAD TAPEWORM

THE recent article by Vergeer[1] prompts me to call attention to my experiments on *Diphyllobothrium latum* (the broad tapeworm) which was published in *Minnesota Medicine*, October 1927, page 614. Since my report was the first demonstration of the fact that North American fishes act as hosts for this worm, Vergeer's report may be looked upon as confirmation of my findings. In my report it was indicated that I had evidence of the fact that there was an endemic area in and about Winnipeg, Manitoba. Since then I have obtained wall-eyed pike from Lake Winnipeg and have found larvae in a great percentage of them, which when fed to dogs produced typical tapeworms of the species *D. latum*. The importance of this is apparent when one learns that a great proportion of the wall-eyed pike sold in the middle western markets comes from Canadian Lakes and that a large proportion of

[1] The *Journal of the American Medical Association*, 90: 673–678.

the fresh fish sold on the Winnipeg market comes from this lake.

A full report of my investigations will be published shortly.

THOMAS B. MAGATH

MAYO CLINIC,
ROCHESTER, MINN.

SCIENTIFIC BOOKS

Crystallographic Tables for the Determination of Minerals. By VICTOR GOLDSCHMIDT (Heidelberg) and SAMUEL G. GORDON (Philadelphia). Philadelphia, Pa., Special Publication No. 2, The Academy of Natural Sciences of Philadelphia, 77 pp., 4 figs., 16 tables, 1928.

THIS is a complete presentation of the most modern methods of dealing with crystal identification by means of two-circle goniometric measurements. In earlier days Professor Federov, of Petrograd, Russia, wrote a "Dictionary of the Mineral Kingdom," which has been published by the Petrograd Academy of Science. This work is a sort of crystallo-chemical analysis of over ten thousand compounds, both organic and inorganic, which had been previously investigated as to crystallographic details; but unfortunately it is much involved with Ferderdov's theories of crystal structure.

The present work is intended for treatment of the unknown crystal which has been measured on the two-circle goniometer. It is very concise. First, it is necessary to identify the crystal system to which the unknown crystal belongs; then its complete identification is accomplished by means of the angles and polar elements as given in the tables. These tables are especially useful because any normal orientation of the crystal will give sufficient data for identification.

Since isometric crystals can not be distinguished from one another by crystal measurement, they are arranged according to luster, then by chemical composition, and lastly according to increasing specific gravity. The tetragonal minerals are arranged according to tangent relations, orientation with reference to either first or second order prism position being allowed for. For the orthorhombic crystals we may use either the linear or polar elements, the tangent or the cotangent. In this connection a supplementary table (Table 7) is used to make the work more complete for every possible orientation. Monoclinic minerals are classified according to prism angles and tangents of these, since the prism zone usually can readily be identified. Triclinic crystals are listed according to projection elements, polar elements and linear elements, and a special table is also provided to aid in correct orientation.

In every table there are cross references to other tables. The index at the end of the book refers directly to the minerals, of which a total of 1,710 species are listed. The book should be very useful to crystallographers in general.

ALFRED C. HAWKINS

RUTGERS UNIVERSITY

SCIENTIFIC APPARATUS AND LABORATORY METHODS

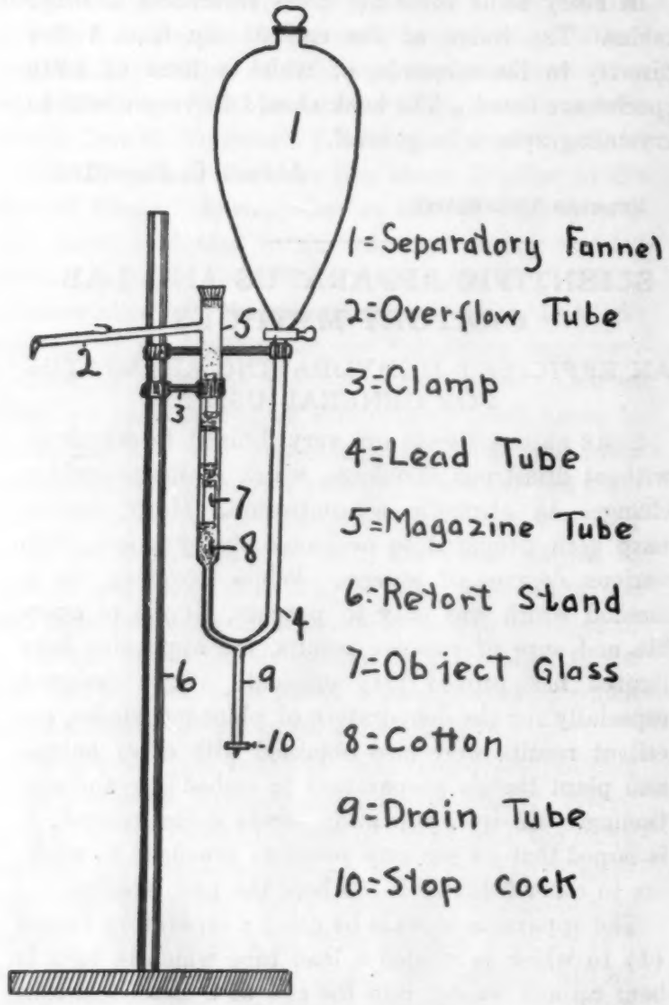
AN EFFICIENT DEHYDRATING APPARATUS FOR GENERAL USE[1]

SOME animal tissues are very difficult to dehydrate without disastrous shrinkage, which is due to sudden changes in alcoholic concentration. Many devices have been prepared to overcome this problem, with various degrees of success. While searching for a method which was easy to procure, simple to operate and sure of positive results, the apparatus here figured has proved very efficient. While designed especially for the dehydration of plant nematodes, excellent results were also obtained with other animal and plant tissues preparatory to embedding and sectioning. As its application seems quite general, it is hoped that its use may prove as beneficial to workers in other fields as it has here the past months.

The apparatus is made by using a separatory funnel (1) to which is welded a lead tube which in turn is bent up and welded into the end of a small test-tube (5), thus formed into the magazine tube. Near the top of the test-tube is inserted the overflow tube (2), which is bent down and drawn out at its end. It will be noted that the insertion of this tube is on a level, or a bit above, with the stop-cock of the separatory funnel, so the apparatus can not run dry. The unattached end of the magazine tube is left open for ease of loading and unloading of material to be dehydrated. Evaporation is minimized by placing a cork in this open end. At the bottom of the bend in the lead tube, a drain tube (9) is welded in, which is fitted at its open end with a glass stop-cock. This allows for quick and complete drainage when an entire change of fluids is desired. All rubber connections are avoided, so there would be no difficulty when such fluids as xylol are to be used. The glass used is Pyrex, due to the fact that soft glass is hard to manipulate, especially in burning the necessary holes through the magazine.[1]

As used by the author, the entire apparatus is mounted on a ring stand by using suitable clamps

[1] The author is indebted to Mr. George Pettengill, of the Oregon State Agricultural College, department of chemistry, who made many valuable suggestions and did the glass work for the apparatus.



and filled with the appropriate fluid. A small piece of absorbent cotton was placed at the bottom of the magazine tube for the lower object-glass to rest on, and also to aid in gradual change in the strength of fluids. The object-glasses are made in the usual way, by selecting a piece of glass tubing a bit smaller in diameter than that of the magazine tube, and cutting into suitable lengths. The ends of the object-glasses were prepared in either of two ways. When the object-glasses were of small diameter, *i.e.*, to be used for very small objects, they were fitted with glass tube-stoppers which had a bit of bolting-cloth stretched across the inner open end. If the object-glasses were of larger diameter, *i.e.*, to be used for larger objects, the ends were heated and slightly flanged so that cheese-cloth, or cloth of suitable mesh, could be tied over the ends. Inside each object-glass a small bit of paper was placed with the record written in waterproof India ink.

The prepared object-glasses were then placed in the magazine tube, one on top of the other. With larger tissues the magazine tube was often filled with small cheesecloth bags, each bag containing the desired tissues and label. The stop-cock of the separatory funnel was then turned so that the fluid passed through the tissues, out the overflow tube and into a dish. The passage of fluid can be controlled so that any amount passes through—from a few cc per day to liters. The dilutions varied 10 per cent., from water to absolute alcohol, and the time of immersion in each dilution was the same. These two factors being constant, the dehydration rate was very gradual, with a minimum of shrinkage of the tissues.

The change of xylol for objects to be mounted in gums, dissolved in that medium or to be imbedded in paraffin, was made a gradual one by using similar methods. The strengths of xylol in absolute alcohol were 10, 25, 50, 75 and 100 per cent.

WILBUR D. COURTNEY

DEPARTMENT OF ZOOLOGY,
OREGON STATE AGRICULTURAL COLLEGE

IMMOBILIZATION OF PARAMECIUM

VARIOUS methods have been suggested from time to time for the immobilization of active ciliates for the purposes of study.

In some recent preliminary experiments on Paramecium with ultra-violet radiation it was observed that cultures of this infusorian, exposed in small embryological dishes filled to a depth of 0.5 cms, were in some cases immobilized to such an extent as to permit of detailed study of ciliary activity, vacuole contraction and formation and the general activities of the organism.

The apparatus employed was an ordinary quartz mercury vapor-lamp, DC voltage 90, current 3–4 amperes. The cultures were placed at a distance of 10 cms from the source of light and exposed for a period of eight minutes.

After one such exposure, the result seemed to offer possibilities for rapidly securing immobilization of Paramecium for class study, and so four other cultures were similarly treated with identical results. This simple procedure may prove a satisfactory means of immobilizing this much-used infusorian for class study.

J. C. BOLAND

DEPARTMENT OF BIOLOGY,
RENSSELAER POLYTECHNIC INSTITUTE,
TROY, N. Y.

A BURETTE CLEANER

I HAVE used a burette cleaner for ten years, but have never seen the method explained in print. In school-work, where there are anywhere from one hundred to one thousand burettes in use during the year, often we find several which will not clean up with chromic acid. After trying chromic acid, which is oxidizing in nature, the burette will become clean very easily if the following method is used:

Wash once with a little 95 per cent. ethyl alcohol and drain. Add about 2 cc of ethyl alcohol 95 per cent., and stand upright under a hood. Now add about 5 cc of concentrated nitric acid, and place a large test-tube over the open end of the burette to prevent any liquid from spatting out. In a very few minutes the reaction begins and throws the contents repeatedly up the full length of the burette. After the reaction has gone to completion, the burette will be clean and the contents are easily washed out.

F. H. FISH

VIRGINIA POLYTECHNIC INSTITUTE,
BLACKSBURG, VA.

SPECIAL ARTICLES

THE PHOTO-MECHANICAL CHANGES IN THE RETINA OF MAMMALS

AT various times attempts have been made to demonstrate the occurrence of pigment migration and positional changes of the visual cells in the retinae of mammals. Conflicting results have been obtained on certain forms, and in only one or two cases, notably that of the ape (Cercopithecus)[1] and that of the dog,[2] have measurable differences in pigment or cone position been observed after light and dark exposures.

The band of retinal pigment is very narrow in most mammals, and in all that I have studied the pigment needles are relatively pale, never having the almost black color observed in fishes and amphibians. In the ape mentioned above, Garten reported a pigment band two or three granules wide in the dark- and three or four granules wide in the light-adapted animal. This slight difference has been accepted by subsequent workers in this field as definitely proving the existence of pigment migration in at least this one member of the mammalian group. The suggestion made by Garten and reaffirmed by Arey[3] that the photomechanical changes occur so quickly in mammalian eyes as to fail to be "caught" by the fixative seems to be invalidated by the work of Detwiler[4] on nocturnal animals, for he was always careful to excise and fix the eyes of dark-adapted animals under faint red light and got negative results.

It has seemed to me that the slight differences found in the pigmentation of the retinae of oppositely-adapted mammals might well have existed before the experiments, and it occurred to me that it would be better to experiment on a single individual, first light-adapting one eye and removing it, then dark-adapting the other eye. Casting about for a form in which it would be easy to remove one eye without much shock or blood loss to the animal, the deer-mouse (Peromyscus maniculatus) was chosen. The eye in this form is very large and protrudes well from the surface of the skull.

My thanks are due to Dr. H. W. Feldman, of this laboratory, who supplied the animals used from his breeding stock and assisted in the operations.

Two animals were used. One was placed in darkness overnight to obtain a standard and for practice in a technical way.

The other, or experimental animal, was placed in diffuse daylight supplemented by the light from a 60-watt lamp and reflector, for five hours. Under ether, one eye was pulled out slightly in its orbit, the optic stalk was ligated with silk thread and the eye snipped off distal to the ligature. The blood loss was negligible, and the animal was allowed to recover in total darkness in which it was kept for twenty hours. At the end of that time the animal was again etherized and the second eye removed under faint red light.

The eyes from both animals were fixed in Perenyi's fluid, embedded in Parlodion and cut 7.5 μ. Sections from both eyes of the experimental animal were mounted on the same slide for convenience, but were not stained. The pigment bands in the two eyes were identical in all respects. They were five or six granules in width, quite uniform in all parts of the eyeball and showed no measurable differences attributable to migration. No attempt was made to measure cone positions, since cones, if present, are indistinguishable from rods in mouse retinae.[4]

I believe this method to be superior to that employing separate animals for the two exposures, and that skilled operators might apply it to other forms in the attempt to settle once and for all this long-standing question as to whether the retinal pigment migrates in mammals and "consequently" in man.

I should like to suggest a more or less philosophical reason why pigment migration should after all not be expected in mammals. If the photo-mechanical changes in the retina be considered from a comparative standpoint, their story is one of degeneration. In the fishes the phenomena are rapid and pronounced; in the amphibians they are less rapid and in general less marked, though still obviously of functional value; in the reptiles only long exposures have resulted in measurable differences in pigment and cone positions in light and darkness. In the mam-

[1] Garten, S., 1907, "*Graefe-Saemisch Handbuch der ges. Augenheilkunde,*" Leipzig, Aufl. 2, Bd. 3, Kap. 12, Anhang; 130 pp., 5 Taf., 49 Textfig.

[2] Chiarini, P., 1906, *Arch. Ital. de Biol.*, Tom. 45, Fasc. 3, pp. 337–352, 8 fig.

[3] Arey, L. B., 1915, SCIENCE, n. s., Vol. 42, pp. 915–916.

[4] Detwiler, S. R., 1924, *J. Comp. Neur.*, Vol. 37.

mals, the phenomena seem to have practically disappeared.

Correlated with this backward orthogenesis is the forward progress in the development of the iris reaction—the familiar dilation in dim light and contraction in strong light of the pupil of the eye. In the fishes the pupil is practically stationary; in the amphibians it expands and contracts within narrow limits; in reptiles the response is about the same as in amphibians, while in the mammals and man the response is very rapid and very extensive. Ophthalmologists are agreed that the chief function of the pupil reaction is to protect the sensitive retina from too strong light and to make available to the retina all the illumination possible in dim light.

Arey[5] has summed up the surmises of previous workers, added his own and evolved an inclusive theory of the adaptive significance of the photomechanical changes based on this very idea—the protection of the sensitive and delicate rods by the pigment and the exposure of the color-perceptive cones in strong light.

It seems to me that we have here one of the not infrequent instances of the replacement of one mechanism by another of similar function through the course of evolution. Certainly the rapid pupil reaction, measured in seconds, is a decided improvement over the sluggish pigment and cell movements whose minimum reaction time at best, in certain fishes, is many minutes.

It must be admitted that the situation in nocturnal animals where both kinds of phenomena are lacking, and in the birds, where both kinds of phenomena are present to a marked degree, is disturbing to this suggestion, but the nocturnal animals have little or no need for either mechanism, and the eyes of birds are so aberrant in many respects that perhaps we are safe in dismissing them in this instance.

GORDON L. WALLS

UNIVERSITY OF MICHIGAN

EGG LAYING OF IXODIPHAGUS CAUCURTEI DU BUYSSON IN LARVAL TICKS

IN connection with experiments in rearing and liberating the French tick parasite (*Ixodiphagus caucurtei* du Buysson) at the Hamilton Laboratory of the Montana state board of entomology, the junior author, who is locally in charge of the work, in conducting an incidental and minor experiment uncovered surprising facts.

Both *I. caucurtei* and *Hunterellus hookeri* Howard, so far as is known, develop only in the nymphal stage of their host ticks, and effective egg-laying in certain experiments conducted by Dr. E. Brumpt, of Paris, and H. P. Wood, of Dallas, Texas, was found to occur only in the nymphs of ticks. Following such egg laying, development has always been found to be immediate and continuous.

Having at hand an abundance of fed larvae of *Dermacentor andersoni* Stiles and a plentiful supply of fresh adults of *I. caucurtei*, the junior author placed about 350 of the former with about ninety of the latter (mixed males and females) in a small glass jar at "room temperature" and in the direct sunlight on August 20, 1927. They were left thus for a period of three hours, when the fed larval ticks were placed in a thermal cabinet at 19° C. for incubation, which is our usual method in rearing ticks. By September 22 all the fed larvae had "molted" to the nymphal stage and the resulting "flat" nymphs were placed in a longevity tube out-of-doors in the "tick yard" under conditions simulating nature. On November 11 these nymphs were placed on a rabbit in the laboratory for feeding and seventy-eight fed nymphs were later recovered. These fed nymphs were placed in a thermal cabinet at 19° C., after which they were examined from day to day. On December 5 it was observed that a few showed the usual mottled appearance characteristic of parasitism, and thirty-two nymphs or 41.02 per cent. of the whole number were eventually isolated as parasitized. From these, nine yielded adult parasites in due time. Nine out of thirty-two is an unusually small proportion to come through to the adult condition and there may or may not be special biological meaning in the small number, since a loss of adult parasites is rather common, especially if the conditions of moisture and temperature are not correct, particularly the humidity.

From the foregoing it is shown that (a) under the conditions stated *I. caucurtei* will deposit eggs in fed larvae; (b) that, while in the case of eggs deposited in nymphal ticks, development of the parasites begins promptly and in suitable temperatures will proceed to the maturing of the parasites, in the case of eggs deposited in fed larval ticks development is delayed; (c) that the living parasite is carried through the quiescent period of the fed larva and is alive in the next stage; (d) that the parasite may remain alive through a resting period of the unfed nymphs prolonged for fifty days (September 22 to November 11); and finally (e) that on the nymphs being fed the parasites will develop to maturity.

These findings suggest the possibility of a more or less established adaptation which had not been suspected.

R. A. COOLEY
GLEN M. KOHLS

BOZEMAN, MONTANA

[5] Arey, L. B., 1919, *J. Comp. Neur.*, Vol. 30.

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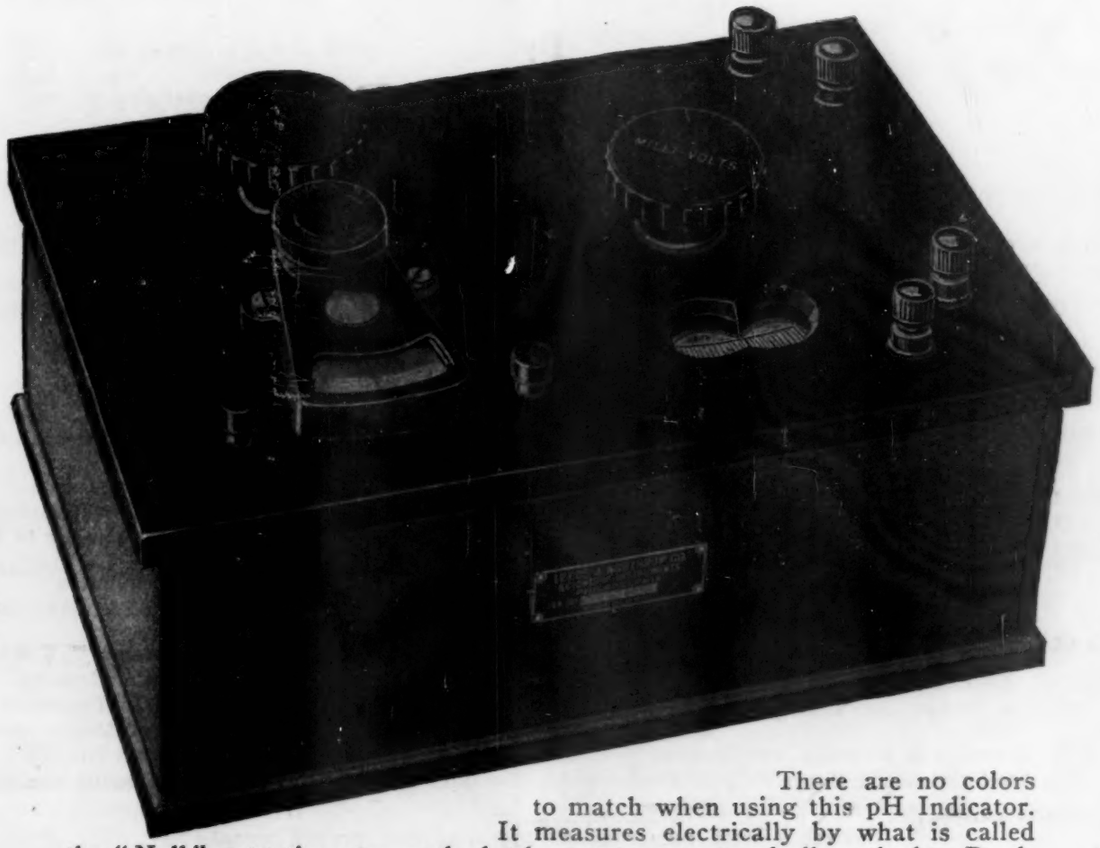

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By

ARNOLD GESELL, Ph.D., M.D.

Director, Yale Psycho-Clinic; Professor of Child Hygiene; Institute of Psychology, Yale University

This is a companion to the author's earlier volume on THE MENTAL GROWTH OF THE PRE-SCHOOL CHILD. Dr. Gesell's new book contains reports of epoch-making studies made since the publication of the earlier work, with special emphasis on the first two years of life.

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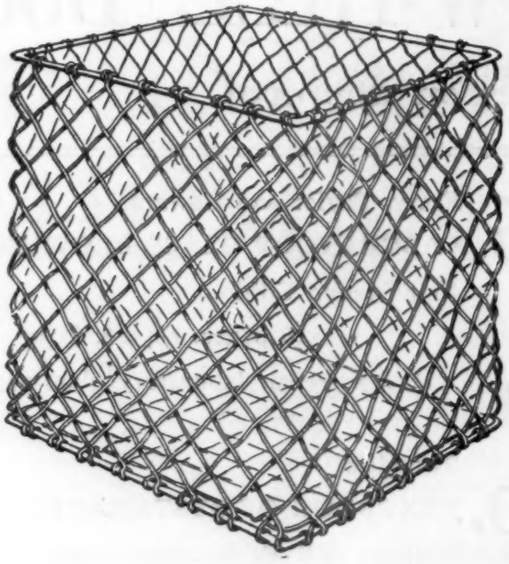

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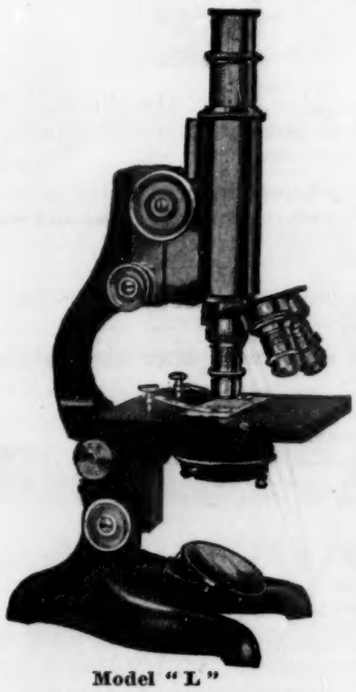

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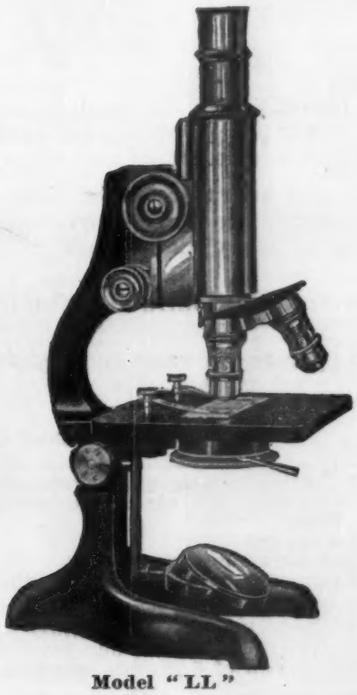

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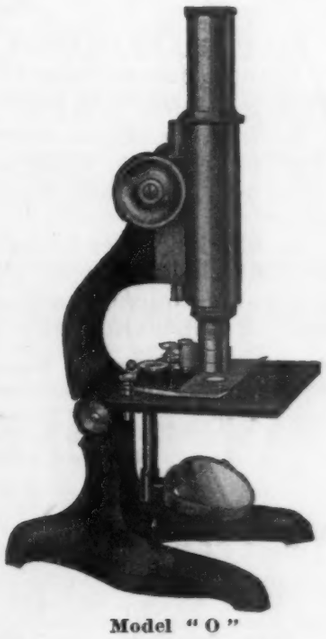

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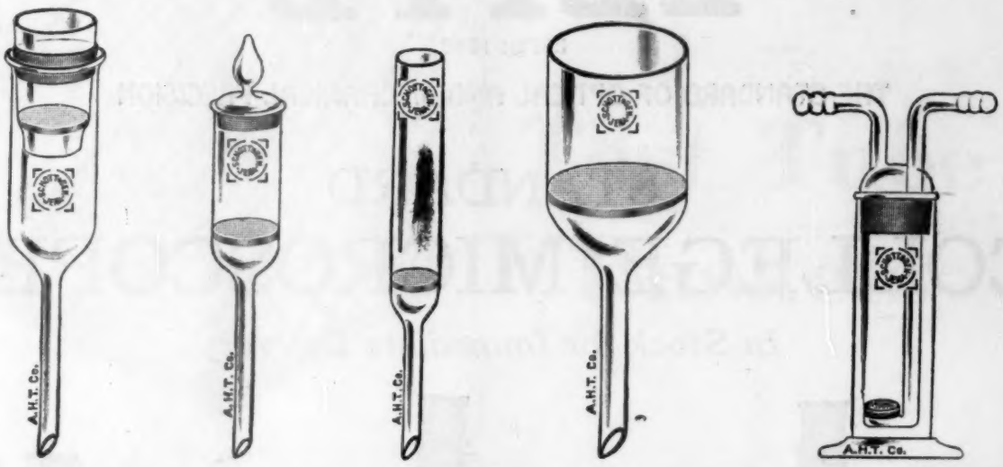

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SCIENCE NEWS

Science Service, Washington, D. C.

COAST GUARD EXPEDITION TO THE ARCTIC

DOES a branch of the Gulf Stream dive to the bottom of the Atlantic Ocean and emerge again far north in Baffin Bay? Is the Labrador current a continuous overflow from the Arctic Ocean? Does the east Greenland current stretch all the way across to Labrador? Why is the west coast of Greenland so much warmer climatically than Baffin Land in the same latitude?

These are some of the outstanding questions of Arctic oceanography that may be solved during the coming summer. About July 10 the U. S. Coast Guard vessel, *Marion*, will sail from Boston for Sydney, Nova Scotia, on the first leg of an expedition to the region between the coast of Labrador and Greenland, an area where the icebergs are supposed to originate. Oceanographically, very little is known about this region at present.

The *Marion* will be under the command of Lieutenant-Commander Edward H. Smith. He has had ten years' service in the ice patrol work, and is also a trained oceanographer, for he spent two years in Europe and several more at Harvard University in oceanographic research. Lieutenant N. G. Ricketts is his first officer, and he also has had extensive experience in the ice patrol.

After April 15, 1912, when the White Star liner *Titanic* struck an iceberg off the Grand Banks of Newfoundland, and went to the bottom with the loss of 1,500 lives, an international convention "for the safety of life at sea" was held at London. From this there resulted the Ice Patrol of the U. S. Coast Guard. Every March two staunch Coast Guard vessels sail from Boston to the ice fields, and remain there until the dangerous season is over, usually about the middle of July. Twice a day these boats broadcast by radio to near-by liners the location of all the ice in the vicinity, so that they can head southward to safety. Since the Coast Guard began this work fourteen years ago only three lives have been lost by collision of a ship with ice.

The science of oceanography has helped to a great degree in solving the problem of making ships more safe in the ice field, Commander Smith told Science Service. "Little was known," he said, "before 1912–14 regarding the drift of the bergs, their rate of melting, and the degree of danger which they formed to passing traffic; except for the fact that they mostly came from Greenland, and that they finally melted in the offshore waters of the Atlantic, which appeared considerable of a mystery.

"Over 3,000 observations," he continued, "have been compiled during the last ten years by the ice patrol vessels. The program has consisted in securing observations of temperature and saltiness at various depths in various positions, carefully selected in the danger area. The ocean currents have been computed from these data in accordance with a mathematical formula. It is based upon the principle that ocean currents are due to differences in the specific gravity of the water. Water will flow from the place where it is relatively light to another region where it is proportionately heavy. This, combined with the fact of earth rotation, permits us to issue regular weekly current maps, similar to the better known weather maps issued daily by the U. S. Weather Bureau.

"In the course of this work we have secured quite a correct picture of current and ice conditions in the immediate area south of Newfoundland, and near the steamship tracks, but little is known of the wild and unexplored stormy region northward between Labrador and Greenland. Our expedition will enter these foggy waters and, it is hoped, will snatch from them a long-contained mystery."

At present the ship is at New London, Conn., where she is being fitted for the expedition. She will be equipped with apparatus for measuring the temperature and saltiness of the ocean water, for observing the ocean currents, and other apparatus unusual in such a boat.

One of the most important instruments with which she will be provided is the sonic depth-finder. With this an accurate measurement can be made of the depth of the water, with far more precision and speed than with the old type sounding-line. This consists of an oscillator, operated electrically and located on the ship's hull, which sends out sound-waves. These travel to the bottom, and are reflected as an echo. Microphones located elsewhere on the ship's hull pick up this echo. The speed of sound-waves through water is well known, and so, from the time it takes the waves to return, the depth can be measured.

Every half hour, day and night, on her cruise, a measurement will be made of the depth. The expedition will sail over an area of 50,000 square miles where no sounding has ever been made and the results will be of great scientific importance.

The Coast Guard expedition will not be alone in this area during the coming months, for the Danish Government is sponsoring a similar exploration with which the Coast Guard will cooperate. The Danish party, on the steamer *Godthaab*, has already sailed from Copenhagen. It is in charge of Commander Riis-Cartensen, of the Royal Danish Navy. Both biological and oceanographical in its scope, it will cover the entire range of west Greenland waters.

TESTING FIREPROOF SAFES

Two buildings, one five stories high, in the heart of Washington, and within less than a mile of the White House, were burned to the ground on June 17 while firemen stood by and watched. No effort was made to save the buildings, though they contained large amounts of lumber and other material, as well as 35 safes, filled with records. The fire was started by S. H. Ingberg, Bureau of Standards scientist.

This unusual fire was made as a scientific experiment, part of a series made by the fire protection section of the Bureau of Standards, of which Mr. Ingberg is in

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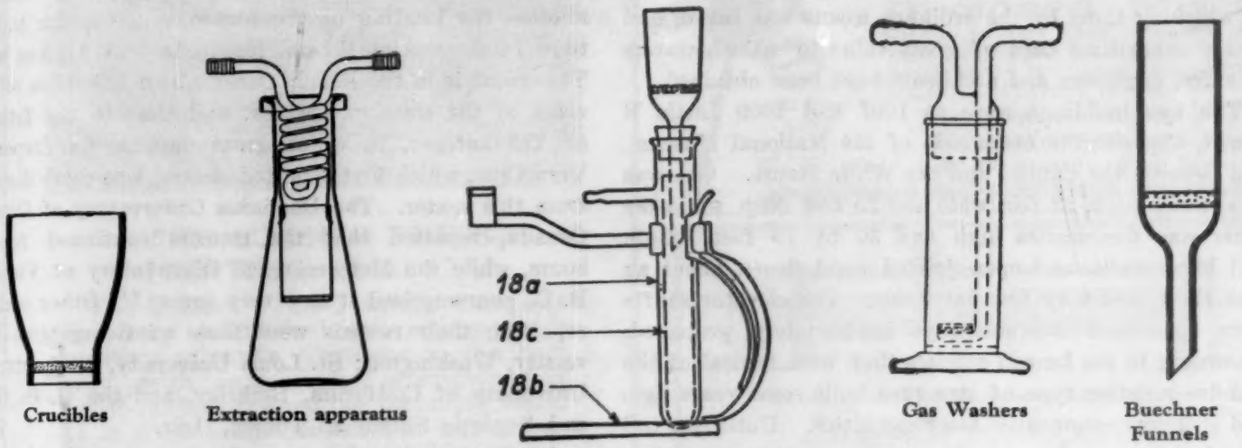

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charge. Previous tests have been made in a large concrete chamber of the bureau, but never before has it been possible to make a careful study of conditions at a full-sized fire, for which preparation had been made months in advance.

With the demolition of many old buildings in Washington, in the triangle south of Pennsylvania Avenue, in order to make way for the government's extensive building program, the idea was conceived of burning one or more as an experiment. Thus the expense and trouble of wrecking them by the ordinary means was saved, and at the same time data of great value to manufacturers of safes, engineers and architects have been obtained.

The two buildings were at 1007 and 1009 Little B Street, opposite the north side of the National Museum, and between the Capitol and the White House. One was two stories high, 22 feet wide and 75 feet deep, while the other was five stories high and 30 by 75 feet. Both had brick walls, and open joisted wood floors, about an inch thick, and very few partitions. The elevator shafts were open and the stairways inadequately protected. According to the bureau officials they were typical of the non-fire resistive type of structure built some years ago, and still very common in American cities. Until last fall they had been used as warehouses.

All the surrounding buildings had been completely demolished several months ago. The two under test were loaded with waste lumber and such material, the weights varying from 7½ to 30 pounds per square foot of floor area. Thirty-five safes, submitted by various manufacturers, were placed at different locations in the buildings. These were numbered inside the doors to permit of identification. They were filled with useless records, so as to determine the degree of protection that they afforded. Each safe also contained a thermometer to record the highest temperature within during the fire, and a clock arranged to stop with a heavy jar. These give records of the time at which each safe fell through the burned-out floor to the ground below.

Mr. Ingberg and his associates observed the fire from a "dugout" in an old boiler room near-by. By means of thermocouples placed in open spaces at 50 advantageous points within the burning buildings, and at 45 points in the débris, connected by wires with instruments in the dugout, the temperatures were measured electrically.

For days after the experimental fire temperature observations were being continued. Several days after the fire the thirty-five safes were still among the débris and too hot to permit them to be removed and opened.

Within an hour after starting the fire the buildings were completely gutted and temperatures estimated to be as high as 3,500 degrees F., above the melting-point of iron, had been reached. Within 15 minutes after the start of the fire some of the thermocouples in the building, by which the temperatures were measured electrically, had reached 2,800 degrees, at which point they melted, and stopped working.

THE MEXICAN EARTHQUAKE

PROBABLE damage and loss of life at Oaxaca and other towns in southern Mexico as the result of an earthquake at 10:14 P. M. Saturday, June 16, was announced by Science Service on Sunday, within 20 hours of the time of the quake, and before reports from the most great damaged area had reached the United States. The announcement was made possible by earthquake wave messages received at six American and Canadian seismological observatories, relayed to Science Service by telegraph and interpreted by the U. S. Coast and Geodetic Survey.

This Science Service earthquake-reporting network allowed the locating of the center of the quake at latitude 14 degrees north and longitude 95.5 degrees west. This point is in the Pacific Ocean about 125 miles off the coast of the state of Oaxaca, and close to the Isthmus of Tehuantepec, in which great damage was reported. Vera Cruz, which first reported shakes, was some distance from this center. The Dominion Observatory at Ottawa, Canada, reported that the tremors continued for six hours, while the Meteorological Observatory at Victoria, B. C., characterized it as "very severe." Other stations reporting their records were those of Georgetown University, Washington; St. Louis University, St. Louis; the University of California, Berkeley, and the U. S. Coast and Geodetic Survey at Tucson, Ariz.

A severe earthquake occurred at very nearly the same center on March 22, and other shocks, also reported by Science Service, were felt in the same region on April 13 and 17. One of these quakes broke open a tomb in the mysterious city of Monte Alban, near Oaxaca, revealing valuable jewel treasures that Mexican archeologists believe will help solve the enigma of the strange pre-historic race that lived there.

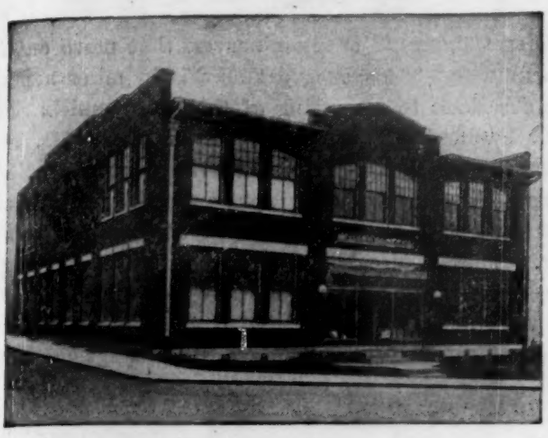
EUROPEAN ROADS

EUROPEAN roads, which fifteen years ago were superior to the American automobile trails of those days, are now far inferior to the hard-surfaces available for touring here in America, Tore Franzen, of Detroit, told the Society of Automotive Engineers recently.

The main roads of the Old World, once the trade routes of the civilized world, have deteriorated as a result of war and lack of proper maintenance. The old stone roads that in many cases date back to the Romans are durable, but very rough, narrow, highly crowned and surfaced with cobblestones and slabs. Other roads are of dirt, rutted and rough, with only the most necessary repairs made by the peasants who live alongside them.

There are two kinds of European motorists, Mr. Franzen discovered in surveying the situation. The dashing sportsman drives his own car and insists upon speeding over poor roads. Most European car owners, however, employ chauffeurs and desire to travel in safety and comfort.

American automobiles are sometimes criticized because they shimmy and shake on European roads. Rough roads and the low tire pressure used cause the springs to deflect deeply and give the riders severe jolts. Thin oil plentifully applied is considered in Europe to be a universal cure for any slight spring or shock-absorber squeaks. But the oil simply puts most shock-absorbers out of commission and makes the springs weak. Mr.



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Those authors who have read proofs will know the correctness of the composition, including the technical scientific terminology. A distinguished scientific man wrote recently to the editor of "Science": "I corrected my first proof a year before you were born and the one I returned yesterday was the first one in my long experience that needed no correction."

The press prints "The Scientific Monthly," "Science," "School and Society," "The American Naturalist" and some twenty other scientific journals and publications. The typography and press-work of these journals will bear comparison with any weekly or monthly publication, although, for example, "Science" must be printed mostly in one day in an edition of over 13,000. The new edition of "The Biographical Directory of American Men of Science" is an example of the work of the press. It can to special advantage print scientific monographs and doctorate dissertations.

Correspondence should be addressed to the secretary, Jaques Cattell, The Science Press Printing Company, Lancaster, Pa.

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THE BRAIN OF THE PORPOISE

MAN'S pride in his well-developed cerebral hemispheres is dealt a severe blow by the statement of Dr. Orthello R. Langworthy, associate in anatomy at the Johns Hopkins Medical School, that the porpoise, generally considered a very stupid animal, has a much larger brain and bigger and more convoluted cerebral hemispheres than man himself.

Dr. Langworthy has been studying the brains of ten specimens caught by himself and associates off Cape Hatteras last February in an expedition financed by the Linton Fund. Porpoises have reached a new importance in the scientific world because of the growing scarcity of whales, which they closely resemble.

As a matter of fact the porpoise is a more highly developed animal from the evolutionary point of view than man, for the porpoise, after reaching the cat or dog stage of development, took up an aquatic habitation and underwent further evolutionary changes to suit his new environment. The foreleg changed to a fin and the hindleg disappeared entirely. The skull broadened at the sides and shortened in front so that the nose was forced up above the eyes where it became a blow hole, while the olfactory nerve was cut off entirely. On the other hand the nerve of hearing is very well developed.

These changes in the brain are now being studied with a view to explaining the evolutionary changes noted in the skull and to determining how much of the change is due to the aquatic environment.

ITEMS

GREASE-MEASURING devices, such as used by filling stations in servicing automobiles, may soon be standardized. Tentative specifications and tolerances for grease-measuring devices were adopted in Washington at the twenty-first National Conference on Weights and Measures. While final adoption by the conference is never made in less than a year's time, this action means that during the next year a close study will be made of the usefulness of the code. In case of standardization, motorists are promised that they will no longer need to worry about their garage men failing to give them the quantity of lubricant they call for.

WEATHER maps now made by San Francisco Weather Bureau officials, covering the Pacific Ocean as far as the Aleutian Islands and the Philippines may aid in long range weather forecasts of the California region and the western United States. So the members of the American Meteorological Society meeting at Pomona College were informed by L. E. Blochman, of Berkeley. In general, said Mr. Blochman, seasons tend to follow the conditions prevailing during October and November, when the California rainy season opens. Sometimes, however, as happened last season, they change. He believes that study of the low pressure area around the Aleutian Islands is of considerable importance.

SOLAR "flames," or prominences, that move out from the sun with speeds as great as 20,000 miles a minute, were described to a meeting of the Astronomical Society of the Pacific by Ferdinand Ellerman, of the Mt. Wilson Observatory. These prominences have been studied by means of the spectroheliograph, an instrument that permits them to be photographed in the light of a single color. They consist largely of hydrogen. Among the interesting ones that he has studied recently, Mr. Ellerman told of one that expanded from a height of 100,000 miles above the sun's surface to more than 200,000 miles a few minutes later.

DEMOCRACY is an affair of the biologists and not the political scientists. This is the conclusion reached by Dr. Michael F. Guyer, head of the zoology department at the University of Wisconsin. For a democracy to survive, it must be carried on by a race having certain qualities of disposition, character and intellect. Because these things are inherited just as a man inherits physical characteristics, such as color of skin, hair and eyes, Dr. Guyer contends, the development of a race having the qualities necessary to operate a democracy successfully rests with the biologists.

GOPHERS, or their ancestors of the Stone Age, cultivated the habit of burrowing assiduously, finding it a great help in the struggle for existence, E. C. O'Roke, University of California investigator, reported to the western section of the American Association for the Advancement of Science. This habit was developed by many different orders of mammals, particularly those belonging to the rodent family, no matter how wide their zoogeographical distribution.

TWO icebergs, one of large size, were within a few hundred miles of the transatlantic steamship routes, on June 18, according to reports received at the U. S. Navy Hydrographic Office in Washington by radio from the Ice Patrol cutter *Modoc*. The *Modoc* was at the time on the New York-Southampton lane, but no ice was in sight. The two bergs, then off St. Johns, Newfoundland, were reported to the *Modoc* from other ships.

EXTRA doses of ultra-violet light are not so good for plants as for animals, it appears from experiments carried on in London by E. M. Delf, K. Ritson and A. Westbrook, working at Kew Gardens and Bedford College. The experiments were undertaken with the idea of finding the possible effect of the light on plants brought from the south to northern countries where there is much less sunshine. Seedlings and older plants were given treatments with quartz mercury vapor lamp, similar to those given human beings. Germination and growth were retarded and in older plants, leaf-formation was partially inhibited and flower-formation and budding were held back.

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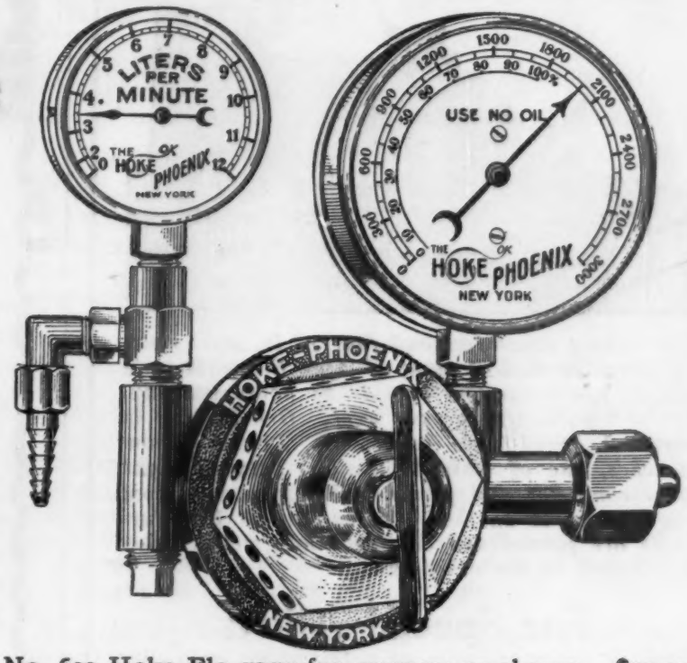

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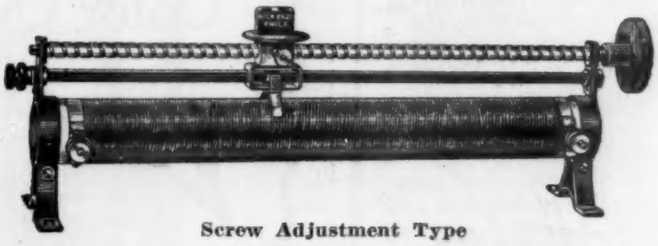

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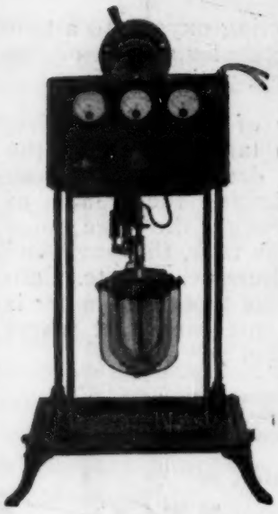

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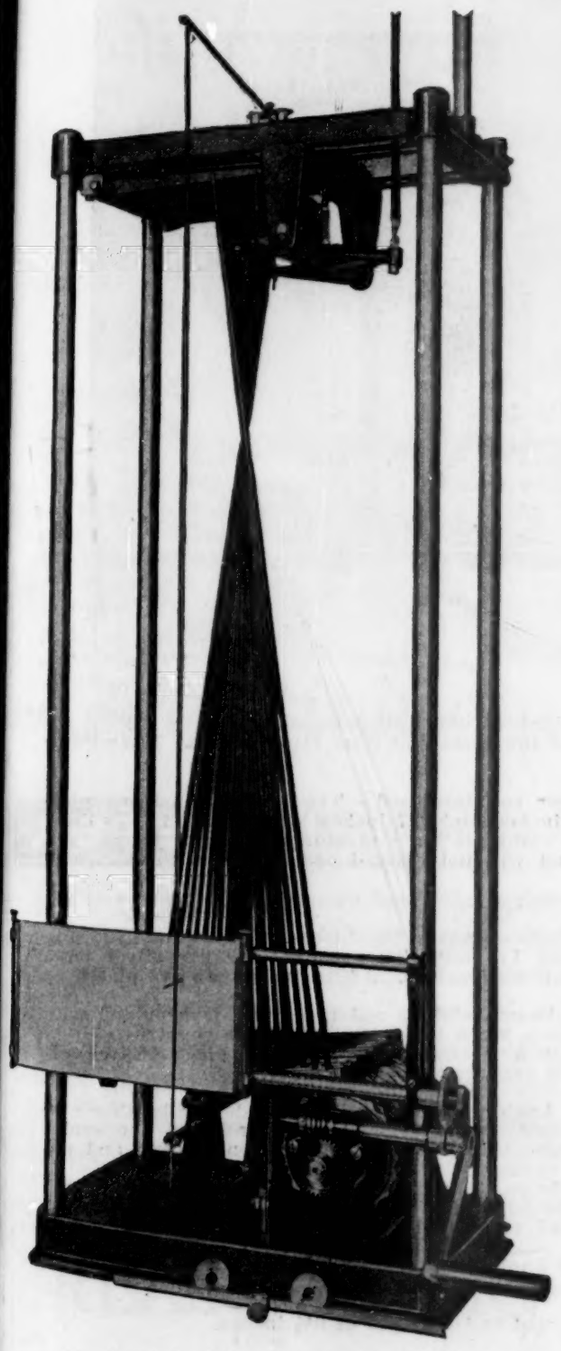

THE apparatus is similar in construction to the original Michelson-Stratton Harmonic Analyzer as described in the Philosophical Magazine of May 1898, and is capable either of drawing the curve corresponding to any Fourier Series, or of determining the coefficients of the Fourier Series which corresponds to any given curve.

In place of the cone of gears as used in the first apparatus, a set of sine cams as suggested by Professor Michelson, is employed to give motion to the lever arms and tension to the springs. The discs with the sine curves accurately cut on the periphery, are made of hard brass and are mounted on a heavy steel shaft on which they can be set to sine or cosine positions. The discs are separated by stationary rings to which they are keyed by a long steel pin which holds them accurately in either of the two different positions. The rotation of the cam shaft is accomplished by a worm wheel and worm.

The rocking levers are made of hard bronze and carry on one end small steel rollers which bear on the cams. The rollers are kept in contact with the cams by a set of adjustable helical springs.

The vertical rods which transmit the motion of the lower levers to the upper levers and springs are made of steel and bear with a sharp point on the rocking levers. The twenty springs attached to the upper levers can be accurately adjusted by means of screws and the adjustment is locked with small nuts. The rocking lever, on which the twenty springs act, rotates on hardened steel knife edges and the tension of the springs is balanced by one strong spring which is adjustable on the vertical rod mounted on top of the frames. (This is not fully shown in the illustration.)

The motion of the rocking lever is transmitted to the recording chart by means of an adjustable lever system which is carefully balanced and works very free of friction. The carriage with the recording chart 28 cm by 15 cm (coordinate paper) is moved by a screw of coarse pitch which is geared to the worm shaft which rotates the cams. The gears can be easily interchanged so as to obtain one period in 25 cm, two periods in 25 cm, and one-half period in 25 cm on the card.

A special divided scale with sliding stop is furnished with the apparatus to facilitate the accurate setting of the vertical rods on the rocking levers. The scale is graduated in 200 parts with the zero mark in the middle.

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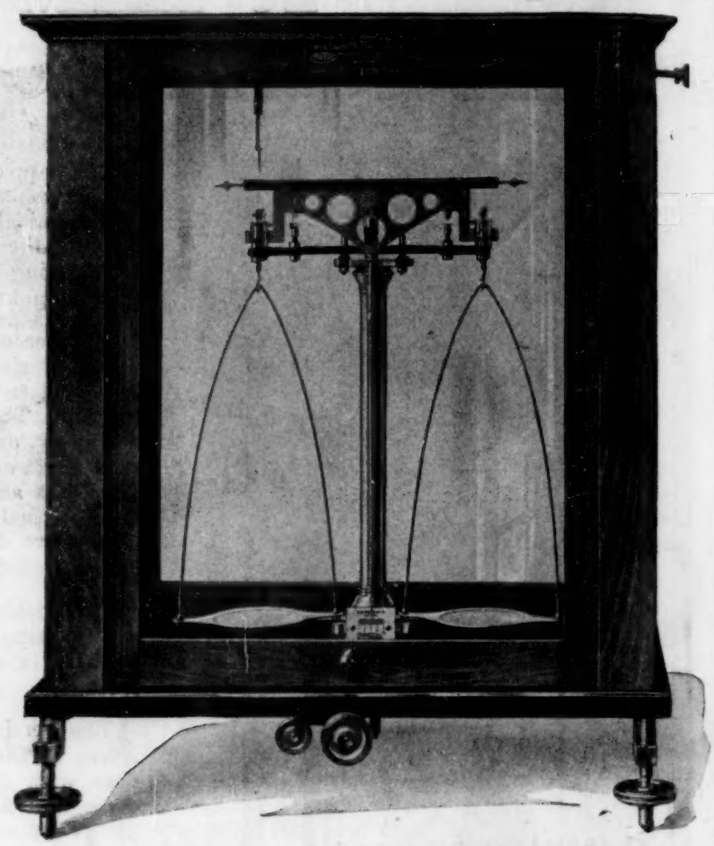

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Sensitivity 1/10 milligram with full load, i.e., a change of weight of one milligram on the beam moves the pointer on the scale 2½ divisions and without load will move the pointer at least 3½ divisions. The pointer will make a complete swing in ten seconds.

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Center Column of brass heavily lacquered of a special grade evenly applied and unequalled for wear, securely fastened to the base.

Beam is made of aluminum and the length between the two knife edges is 6¾ inches. The beam is graduated on both sides in 50 divisions, each division representing 1/5 mg. The graduations are silver on a black background. It will carry a load of 200 grams with perfect safety. Adjusting screws are placed on each end of the beam.

Rider Carrier of simple and effective construction of the well known sliding rod type, and is provided with patented rider hook which carries the rider, locked in a loop, when not in use and is so constructed that with a turn of the rod it will place the rider on the beam in a vertical position at any place desired. It is also so constructed as to prevent the possibility of loss in derangement of the rider.

Knife Edges and Planes of finest Russian agate throughout.

Release and Arrest—The release mechanism is controlled by a knob at the front and outside the balance case and consists of a staff supported by the center column, heavily brass lacquered. It releases the center knife edge and the end knife edges simultaneously, thus preventing possible injury when loading and unloading—it supports the beam when not in use, free from contact with the knife edges or planes.

Pointer and Pointer Scale—The pointer scale is of ivory and is so graduated that the pointer moves in the same vertical plane as the graduations. The pointer can be adjusted to quick sensitivity by shifting the sliding weight, thereby obtaining the center of gravity, and is also nickeled and lacquered by a special method to prevent rust and corrosion.

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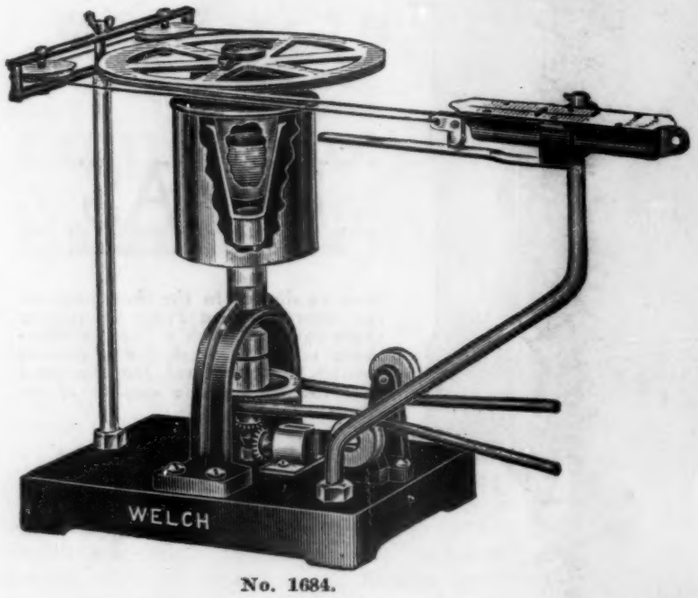

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